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SPEECHES AT THE UNVEILING OF THE SHACKLETON MEMORIAL

AT the invitation of the Memorial Committee the company assembled in the Hall of the Society at 3 p.m. on Saturday 9 January 1932.

The Most Honourable the MARQUESS OF ZETLAND, Chairman of the Memorial Committee, addressing the President of the Society, said:

My first duty is to thank you, Sir, and through you the Council of the Royal Geographical Society, for agreeing to take into your keeping the statue which forms part of the Memorial which the Committee, formed for the purpose, have raised to the late Sir Ernest Shackleton. Of the man himself I shall have an opportunity of speaking later; for the moment I confine myself to a brief statement of the manner in which the Committee has discharged the task entrusted to it. In all a sum of rather more than £3300, including interest which has from time to time accrued, has been at our disposal. Some part of this we were able to allot in the form of an annuity to Mrs. Shackleton, the mother of the explorer, until the date of her death. It had been in our mind to assist, had this been necessary, with the education of Shackleton's children; but at the specific request of Lady Shackleton no part of our fund was used for that purpose. Part was spent in erecting in South Georgia, in the vicinity of Shackleton's last resting-place, a granite monument; and part will be spent in the acquisition of a bronze bust to be entrusted to the keeping of one of the public institutions in this country. But the greater part has been devoted to the striking statue of Shackleton in Polar costume so finely executed by Mr. Charles Jagger, which is to be unveiled to-day.

Before asking Dr. Mill to address you, it would, I know, be the wish of the Memorial Committee that I should take this opportunity of expressing to Mr. Wordie, a colleague and admirer of Shackleton, our unstinted gratitude for the work which he has done as secretary to the committee. The greater part of the burden has fallen upon his shoulders, and it is not too much to say that without his devoted services the goal which the Committee set before itself would never have been reached. I now call upon Dr. Mill, a member of the Committee, to address you.

DR. HUGH ROBERT MILL:

Twenty-three years ago to-day, on 9 January 1909, Shackleton stood on the summit of the ice-cap 400 miles nearer the heart of the Antarctic than any

predecessor, though still 100 miles from his hoped-for goal. Weary, hungry, cold, and disappointed he yet tingled for triumph in the greatness of his achievement. To-day, ten years after his death in the *Quest*, the friends who followed, admired, and loved him meet to enshrine in this temple of Geography a memorial which will mark for ever the high precedence he won amongst the heroes of exploration. In this time of gloom and disillusion it is good indeed to warm our hearts in the glow of romantic aspiration, high attainment, and happy optimism which his memory can never cease to radiate.

Shackleton trained as a polar explorer on the National Antarctic Expedition of 1901, and accompanied his leader to the farthest south, an advance of 200 miles. He could go no farther then; but in his mind he registered the determination to return and to push on to the Pole. So in 1907 Shackleton brought the immense driving power of his impetuous but persistent energy to bear on the creation of an expedition which should be not only new but of a new kind. He planned and organized it on new lines, he raised the funds by new means, and to its service he brought new devices of stowage, transport, and equipment. Those novelties of a quarter of a century since were so effective and so essential that they have become the common form of all recent expeditions, and only those who remember the tyranny of the old traditions of polar exploration can understand how great were the reforms made by Shackleton.

He chose a land party distinct from the ship's company, treating all its members on an equality, though entrusting each with personal responsibility for a special department of investigation or service. Although he consulted authorities on every point Shackleton did not follow any master; advice or warning only stimulated his originality. He was the first to bring a motor car to the Antarctic, and though its life was short it was a merry and useful one. First of all polar explorers he illuminated the winter quarters by acetylene gas, banishing the bugbear of perpetual darkness. He personally chose and tested the rations and their packing. For the long southern journey he introduced Manchurian ponies, also for the first time, to draw sledges so designed that when the animals failed they could be hauled by men. He made use of improved methods of camping, of handling the sledges, and of marking the track, with the result that he accelerated the rate of sledge travelling to a surprising extent. Starting from the same base as the *Discovery* expedition, he laid out the route far enough to the east to escape at the outset the worst crevassed area of the Barrier.

These and a myriad improvements in detail enabled Shackleton and his three companions to reach the former "farthest south" in twenty-three days instead of thirty-three. Six days beyond this point he discovered the Beardmore Glacier stretching gently upwards like a broad highway to the Pole through a vast valley cleft in the mountain wall. Fair to see, the road was rough to travel; the last pony was lost in the waste of jagged ice-masses, and by their own strength the men dragged their sledges 120 miles from the level Barrier up to the edge of the plateau nearly 10,000 feet above the sea, and for 180 miles farther until within 100 nautical miles of the South Pole. At intervals of about 100 miles on the outward way the loads were lightened by leaving a supply of food and fuel just sufficient, if no delays occurred, to carry the party back to the depot behind. The only clue to guide the returning travellers to

those icy molehills was the faint track left by their outward-bound sledge in the snow and a few snow-pillars. To miss any one of them would mean certain death. In order to compensate for food consumed during unforeseen delays rations were cut down to the very minimum that could support life; but nothing could be done to make up for loss of time as ultimate safety depended on returning to the base before winter forced the *Nimrod* to leave.

Shackleton held on his southward way until the last possible moment; then he turned. He had solved the problem of reaching the Pole, and but for the delays which no foresight could avoid he would have reached it. The return journey was a grim and doubtful race with Death; but from point to point the race was won. Each tiny cache of food and fuel was found and reached just as the supplies carried gave out; once after the party had been forty hours without a meal. Never was safety plucked from danger by so close a call. In spite of all difficulties the route was mapped so completely and accurately as to furnish a trustworthy guide to the intrepid party which slogged on to the Pole itself three years later. Shackleton planned and his comrades performed two other unprecedented feats on this expedition: the ascent to the active crater of Mount Erebus, 13,000 feet above the frozen sea, and the attainment of the South Magnetic Pole.

The labour of the expedition over, Shackleton carried out two others almost equally Herculean, the writing and publication in eight months of two great volumes which bore no sign of haste in literary style or artistic illustration, and a lecture tour of the world with the first kinematograph film ever taken in the far South, to raise funds with which to pay off the guarantors whose support had made the expedition possible.

Shackleton's ambition grew with his success. His fertile brain conceived new plans and devised new methods to achieve them, no full account of which has ever appeared. The Imperial Trans-Antarctic Expedition was launched in the unforeseen eclipse of peaceful enterprise just as the shadow of the Great War swept over the world. Shackleton, starting only when his offer of the ship to the Admiralty for war purposes was declined, hoped to land in the south of the Weddell Sea, to sledge across Antarctica to the South Pole and on to the Beardmore Glacier, where a party sent out by him to the Ross Sea had deposited stores to ensure his safe arrival at McMurdo Sound.

No plans could have been better laid; but the tide of Shackleton's fortune had turned. The *Endurance* was nipped in the ice of the Weddell Sea and drifted slowly northward to destruction. As in a Greek tragedy disaster after disaster fell upon the expedition as the leader waited helpless but undaunted on the splitting and dwindling floe, and as he battled later making his boldness wait on caution in the small boats amongst the huge seas of the wildest ocean in the world. His spirits rose to meet the shocks of doom and in the end he brought back all his men, shaken indeed, but not shattered by the ordeal.

His first expedition established Shackleton as an explorer unequalled in the audacity of attack; his second revealed him as a man at grips with Fate, prudent and cautious in retreat. In both he "was ever a fighter." Strongly contrasted qualities met in Shackleton's many-sided personality, reflecting his descent from quiet, learned, solid Yorkshire Quakers on the one side, and from quick-witted, impulsive, and pugnacious Irish ancestors on the other. Physically he

was strong, mentally he was alert, morally he was sympathetic with all that is good; but his success and his fortitude cannot be ascribed to devotion to any one ideal. Many aims attracted him, but perhaps his strongest motive was a passion for self-expression in adventurous action: in all his strivings he looked high and "hitched his wagon to a star." His daring often looked rash, but it stopped just short of recklessness. His caution only blossomed in the field of danger, and then it concerned others, not himself. In moments of crisis his decisions were so swift and his action so prompt that he seemed to act on some impulse of intuition, though really it was quick observation and rapid reasoning that lit his way. His mind was so balanced as to be sensitive to the faintest indications, and at its highest tension his choice was always instantaneous and right.

Shackleton loved poetry and he had the power of a poet to imagine all the possible eventualities of any situation; he had also the patient precision of a storekeeper in providing for each emergency that he foresaw. In everything he did he overflowed with a self-confident cheeriness which carried every one with him wherever he would have them go. No leader was ever more loved and respected by his followers; their devotion owed nothing to authority, but everything to the warmth of genuine comradeship which made his will the will of all who were with him. When dangers thickened round him the lighter side of his nature faded and the deep-seated greatness of his character rose and possessed him entirely. This is the aspect which he bears in the noble statue now to be unveiled, all fortitude and patience; but we, the friends of his dynamic youth, can animate the bronze with the memory of his keen and humorous eye, his vibrant voice, his winning smile and rollicking laughter, all speaking to us of his quixotic generosity, his delicate tact, and his overflowing good fellowship.

THE MARQUESS OF ZETLAND:

With admirable lucidity and with a few strokes of a master brush Dr. Mill has painted for us a vivid picture of the achievement on which, as he has told us, Shackleton's claim to fame must ultimately rest. And I ask myself what was the outstanding feature of the achievement—the journey of 1909, when Shackleton with three companions forced his way over 366 miles of hitherto untrodden ice and snow from the southernmost point reached under the leadership of Scott in 1902, to a spot 100 miles only from the Southern Pole? To me, looking at the matter with the eyes of a layman having no personal experience of Arctic travel, it was the extent to which the planning, the financing, the organizing, and, in a sense, the final execution of the project were the work of a single man. There was no committee of organization, no public appeal for funds, no Government help—just an individual fired by a great ambition working away doggedly and with unflagging optimism to render possible the attainment of a distant but alluring goal. "I have had three years' struggle and have tackled seventy-odd rich men," he wrote on 4 February 1907; and on February 11, with no fanfare of trumpets, but unassumingly at a dinner of the Kosmos Club, his plans for the conquest of the Antarctic were made known. That seems to me to have been typical of the man—strong, confident, self-contained.

It is significant, surely, that on Shackleton's mere promise to make good the

cost out of the proceeds of writings and lectures which must obviously be dependent on success, shrewd, hard-headed men of business should have been found willing to guarantee the sum required; significant too that fellow travellers, familiar with the trials and the risks of Polar exploration, should have been ready to follow without question wherever Shackleton chose to lead. Here, clearly, was a man of parts inviting something more than passing notice. He was, in fact, a striking example of a type: a type which has sent forth into all lands pioneers in exploration, in commerce, in industry, and in administration; an adventurous and a ruling type; a type which seems always to have flourished on British soil; one without which Britain would have remained but an insignificant island and Greater Britain would never have come to be. Let us then, since not the least of the objects which we have held in view in raising this memorial to him has been to direct attention to the example which he provides for future explorers of our race, devote a few minutes to a study of his character and personality.

As a boy Shackleton was surely not the sort that you would have expected to break away from the family tradition which suggested, for the most part, a studious and quiet existence. He loved music and poetry and he was markedly religious, characteristics which at first sight might be expected to find a more congenial setting within a study's walls than amid the harsh and crude surroundings of the world's unbeaten tracks. Yet such characteristics are indications of emotional deeps where lie dormant forces which, when rendered active by stimulus from without, are capable of influencing profoundly human action, notable among such forces, idealism and ambition. History abounds with examples of such cases. As a young man, Evelyn Baring, afterwards Earl of Cromer, now known throughout the world as the Maker of Modern Egypt, was conscious of not the smallest tittle of ambition, and it is quite likely that, but for his chance meeting in the island of Corfu with the lovely English girl who fourteen years afterwards became Mrs. Baring and subsequently Lady Cromer, he would have lived and died unknown. Ambition came to the surface of the emotional deeps in Shackleton's nature as the result of a similar stimulus from without; for in 1897 he met Miss Emily Dorman, who seven years later became Mrs., and afterwards Lady, Shackleton. "In my bunk that night," wrote Mr. Dunsmore, after a talk with Shackleton on board the *Flintshire*, the ship on which the two of them were serving in 1897, "I felt convinced that the ambition of that man's life was to do something worthy, not only for himself but for her."

Given ambition, it is curious how often the particular direction in which it carries a man seems to be the result of accident. It was a whole series of apparent accidents that took Evelyn Baring to the shores of Egypt; similarly Shackleton's choice of a seafaring career which led him in due course to the frozen and inhospitable wastes that rise from the depths of the Antarctic Ocean, seems to have been purely accidental. All that we know is that at an early age an illustrated book of Arctic travel, Mr. C. F. Hall's 'Life With the Eskimo,' came into his hands and that thenceforth he read all that he could obtain about Polar exploration; and further that contrary to his father's hope that his son might follow in his footsteps as a doctor, young Shackleton at the age of sixteen went to sea.

I am going to indulge in a generalization; but before doing so may I remind you how deeply the characteristics of which I have been speaking were implanted in young Shackleton's nature. Life before the mast in a sailing clipper was little calculated to cultivate the finer feelings; yet it did little to choke the idealism which permeated young Shackleton's being. He was afraid that he would be laughed at when he said his prayers, but "the first night I took out my Bible," he wrote, "they all stopped talking and laughing, and now every one of them reads theirs. . . ." And the illimitable expanses of sea and sky stimulated the poetic imagery which welled up from his innermost being—"Many a painter would have given half of what he possessed to have been able to catch the fading tints of the red and golden sunset we had last night," he wrote when still in his 'teens, and "if you wish to see Nature robed in her mantle of might, look at a storm at sea; if you want to see her robed in her mantle of glory, look at a sunset at sea."

Now for my generalization, which is this, that such natures, if they are to function to advantage, must pass through the crucible of stern and great events. It is in crises that such men attain to their full stature; in the bearing of responsibility and the wielding of authority that they rise to their true heights. In the routine life of a humdrum every-day existence their talents are apt to run to waste. Shackleton provides us with a striking example of the force of this generalization. In England, when not engaged in planning and organizing his Polar expeditions, his restless spirit sought distraction in divers enterprises—as Secretary of the Royal Scottish Geographical Society, as a candidate for Parliament; in journalism and in business, often of a highly speculative character, in which he was always going to, but never did, make a fortune. Let it be said in passing that his ambition to make a fortune was the outcome not of any sordid love of money, but of his vivid imagination which caused him to revel in the prospect of endowing his wife and family with affluence and of wielding the power which the command of riches is generally supposed to give. In actual practice he was reckless in his generosity. Appreciable sums of money which flowed in as a result of his lectures in New Zealand on the eve of his expedition in 1908, sums badly needed for the purposes of the expedition itself, he devoted to local charities. This was an episode oft repeated throughout his career. He had, in fact, much of the spirit of the gambler; his delight lay not in the actual acquisition of wealth but in the prospect of dramatic throws with fortune and in the quixotic spending of such riches as happened to come his way.

The prospect of fame, and possibly of fortune, was not without its influence in directing Shackleton's gaze in the first instance towards the Southern Pole; but unless I have gravely misread his character a subtler and profounder influence was at work, namely, an idealism of a high order: the idealism on whose wings the spirit of man seeks to rise superior to the limitations of his material environment, finding its reward less in the fruits of victory than in the actual process of attaining; an idealism akin to that which led Mallory and Irvine to a glorious death far from the haunts and the huckstering of men, high on the topmost pinnacle of earth. Thus it was, as we should expect, when warring with the stark realities and the constant dangers of the Antarctic that Shackleton was at his best. It was when thus tested that his powers of leader-

ship, his resource and judgment, his courage and endurance came into play. It is a remarkable tribute to his qualities that he never lost a life in any one of the expeditions that he led.

Let those who would assess this fact at its true value study the amazing retreat of the members of the Trans-Antarctic Expedition after the loss of the *Endurance* in the ice in 1915. It may be argued that for a single moment—and that a fatal one—Shackleton's judgment failed him; but no one can harbour feelings other than those of the highest admiration for the heroic qualities which he displayed during those long and nerve-shattering weeks when he and his party drifted helplessly on the ice floe; during the desperate battle with the waters when, their very world cracking and dissolving beneath them under the influence of the warmer waters into which they had drifted, they made in three small boats across 100 miles of turbulent ocean for Elephant Island; during the seventeen interminable days of strain and terror when with five companions he fought his way in one small boat across 800 miles of water from Elephant Island to South Georgia; and finally during that crowning incident of courage and endurance when with two companions but without guides or maps or resting-places, he set forth to cross the snow-clad and untrodden range of mountains which lay between him and help in the shape of the small population of a whaling station. One would have to search long, indeed, to find in the annals of any Northern race a Saga of the Sea more thrilling in its incidents, more moving in its emotional appeal, than that set forth with so fine an understanding in the pages of Dr. Mill's biography.

Such is the man whose memory we seek to perpetuate as an example to his race, by means of the statue of which I now invite you, Sir, as President of the Royal Geographical Society, to accept the custody.

ADMIRAL SIR WILLIAM GOODENOUGH (President R.G.S.):

Lord Zetland: Before all else may I, at the request of Lady Shackleton and her family, offer to you and your Committee their sincere thanks for all your care in raising and administering the fund which has led to this ceremony. It is with feelings of pride and reverence that on behalf of the Royal Geographical Society I accept from you and the Committee of the Shackleton National Memorial the charge of this statue. It will serve to remind us and all who pass by, of a man who had he lived in the golden age would have been a Drake or a Raleigh; of one among those men whose names encircle this hall as they themselves encircled the world; of one to whom adventure was an inspiration, danger an incentive. Imbued with the true spirit of Polar exploration he counted no cost to himself, but was ever mindful of his companions; a great leader of men, beloved and trusted by his followers.

THE VOYAGE OF THE R.R.S. *DISCOVERY II:* SURVEYS AND SOUNDINGS: *A paper read at the Evening Meeting of the Society on 14 December 1931, by*

STANLEY KEMP, SC.D., F.R.S.

THE work which the *Discovery* Committee is undertaking in the Antarctic is primarily concerned with a study of the biology and hydrology of the Southern Ocean—more particularly of those areas in which the whaling industry is centred. It is on this work that our energies have mainly been concentrated, and most of our time has thus been spent in carrying out long scientific programmes at a considerable distance from the land. Though it has always been hoped that opportunity would be found for surveying the little-known coasts that we visit it is only recently that these hopes have been realized.

In our first ship, the R.R.S. *Discovery*, originally built for Captain Scott, we found ourselves very fully occupied with routine scientific work, and though our navigating officer, Lieut.-Comdr. J. M. Chaplin, R.N., eagerly seized ever opportunity that presented itself, very little survey work was in fact accomplished. At a later date Lieut.-Comdr. Chaplin was detached for special surveys in South Georgia, and during the past few years, with a motor boat, an assistant, and four men, he has charted a considerable part of the island and surveyed all its more important harbours in detail. The newly published charts of the island are based largely upon his work.

Our new ship, the R.R.S. *Discovery II*, built in 1929, was specially designed for the Committee's work, and has proved an unqualified success. Her comparatively high speed and very large bunker capacity have allowed us to use our time to better advantage, and we have been able to put through scientific programmes far more expeditiously than before. It has thus happened that in our first commission we have been able to make some additions to our knowledge of certain little-known islands in the Atlantic sector of the Antarctic, and it is this work which is summarized in the present paper.

We count ourselves fortunate in having as our Chief Officer and Navigator, Lieut. A. L. Nelson, R.N.R. Acting under the instructions of Comdr. W. M. Carey, R.N. (retd.), he has shown an enthusiasm that has never flagged, even in the most trying conditions, and though all the ship's company have co-operated heartily, it is to him more than to any other single member that the success of our survey work is due. Both Comdr. Carey and Lieut. Nelson are at present away in the *Discovery II* on her second commission.

The surveys we have made have all been by running survey. The method is too well known to call for description, and though it is one of the least accurate, in the hands of a skilled navigator it can yield excellent results. I am myself convinced that in the sort of places we have been visiting running survey is the only practicable method. With us, as with any vessel operating in these distant waters, time is a factor of the greatest importance, and any other method would demand more than we could give. The weather is most precarious and harbours are few and far between. Landings are nearly always difficult, sometimes almost impossible, and to effect them many days would often be spent in awaiting suitable sea conditions. There is moreover so much work to be done

that fully detailed surveys would take a vast number of years to accomplish even if the means were available.

Our surveys have been made primarily from the navigational point of view: to fix the land by positions obtained astronomically, to plot its coast-line and outlying dangers, to explore possible anchorages and harbours, and to determine the heights of the more conspicuous peaks. The value of the work has been increased by the large number of soundings we have been able to take with our echo-sounding machines. Working inshore they have seldom been taken less frequently than one per minute, and when there is necessity this speed can be doubled or trebled. At the same time we have made notes on the topography and fauna, and the land has been photographed and sketched from various points of view. The photographs illustrating this paper have all been taken by our surgeon, Lieut.-Col. E. H. Marshall, D.S.O., whose skill in this work has contributed largely to the value of our results. Unfortunately we had no geologist with us, and in this subject and in physiography I am afraid that our deficiencies are apparent.

We left England in the *Discovery II* in December 1929, and on our arrival in South Georgia it was our first duty to repeat a survey of the biological and hydrological conditions on the whaling grounds which had been carried out for several seasons previously. In the new ship this was completed very quickly, and on February 21 we began our next work—a line of observations to the South Sandwich Islands and thence westwards to the Burdwood Bank. Shortly after leaving South Georgia we struck a westerly gale, unusual even in these stormy seas for its violence, and some minor damage was done on board. But we found a lee behind one of the enormous tabular icebergs which sometimes occur in these waters and rode out the latter part of the gale in comfort. We never ascertained the full length of this berg, but we skirted its northern edge for 35 miles before reaching its eastern end. A day later in improved weather we resumed our course and we reached Zavodovski, the most northerly island of the South Sandwich group, on February 26.

We had already heard that the season 1929/30 was remarkable for the small amount of pack-ice that was to be found: the pelagic whalers, who normally operate along the ice-edge, were working much farther south than they had ever done before. Zavodovski we found to be entirely clear of ice, and after lying under its lee for two whole days in another gale of great violence we steamed slowly round the island and made our first running survey. At the next island, Visokoi, and again at the Candlemas group, we found no pack-ice, and it became apparent that the season was indeed exceptional. The South Sandwich Islands lie in the direct path of the drift from the Weddell Sea, and great quantities of pack-ice are generally to be found around them. At some period in each normal summer the more northerly islands are probably free of ice, but they are frequently unapproachable, and attempts to reach the southern members of the group have often failed. In winter it is to be supposed that all of them are closely invested with pack. We thus had reason to believe ourselves particularly fortunate, and both Comdr. Carey and I felt that so good an opportunity should not be neglected. We therefore telegraphed to the *Discovery* Committee, and postponing our prearranged programme, we spent the next few weeks in examining the islands. Since pack-ice might arrive at any moment,

we steamed direct to the southernmost group, which also was quite clear, and then worked northwards, surveying each island in turn. We reached Zavodovski on February 26 and finished the last of the islands, Leskov, on March 18. The whole survey thus occupied twenty-one days, during some of which we were delayed by bad weather. These days however were not entirely wasted, as on almost all of them we were able to trawl or dredge. The weather throughout was cloudy, sometimes with thick mist, but sights of sun or stars were obtained at all the islands. Temperatures were low for summer, and for a whole week the thermometer did not rise above zero.

The South Sandwich Islands were first found by Captain Cook in 1775. After his rediscovery of South Georgia, where he landed and took formal possession, Cook sailed south in his attempt to prove or disprove the existence of an Antarctic continent. He turned east in about 60° S., and on the morning of January 31 he sighted three rocky islets with elevated snow-clad land behind them. He called the outermost rock Freezeland Peak, and the land beyond it Cape Bristol. To the south he found other land which he named Southern Thule "because it is the most southern land that has ever yet been discovered," and to the north he found Cape Montagu. Cook thought he could see land to the eastward connecting these three, and he says, "I was sorry I could not determine this with greater certainty; but prudence would not permit me to venture near a coast, subject to thick fogs, on which there was no anchorage; where every port was blocked or filled up with ice; and the whole country, from the summits of the mountains down to the very brink of the cliffs which terminate the coast, covered many fathoms thick with everlasting snow. The cliffs alone was all which was to be seen like land." Still farther to the north more land was sighted, which "under the supposition of its being an island," received the name of Saunders Isle, and beyond it a group of two islands, called Candlemas Islands after the day on which they were found. Cook then turned east and thus missed finding the three northernmost members of the group. In his Journal on February 6 Cook wrote: "I concluded that what we had seen, which I named Sandwich Land, was either a group of islands, or else a point of a continent. For I firmly believe that there is a track of land near the pole which is the source of most of the ice that is spread over this vast Southern Ocean."

Forty-five years later, in 1820, Cook's discoveries were completed and extended by the remarkable voyage of Captain F. G. von Bellingshausen of the Imperial Russian Navy. He found the three northern islands, Zavodovski, Leskov, and Visokoi, and by circumnavigating all the others he proved conclusively that they were islands and not parts of an Antarctic continent. He pushed far to the south, through much pack-ice, and reported that in 65° 25′ S., with a range of 45 miles from the look-out, no continuation of the group towards the south was to be seen. He stated that both the Candlemas group and Southern Thule consisted of three islands, and the Atlas which accompanies his report contains sketches and plans of various members of the group.*

Up till now the charts of these little-known islands have been based solely

*We were particularly fortunate in having on board a folio of Notes on the South Sandwich Islands, compiled in the Hydrographic Office of the Admiralty, which contained translations of the relevant parts of Bellingshausen's narrative and reproductions of his sketches.

on the work done by Cook and Bellingshausen, for though they have been visited on various occasions (more often no doubt than published records indicate) no survey work of any importance has been attempted. The only exceptions to this statement are certain sketch-plans, made of some of the islands by C. A. Larsen, the whaling pioneer, and a plan of Zavodovski made by the *Quest* after the death of Sir Ernest Shackleton, under the command of Comdr. Frank Wild.*

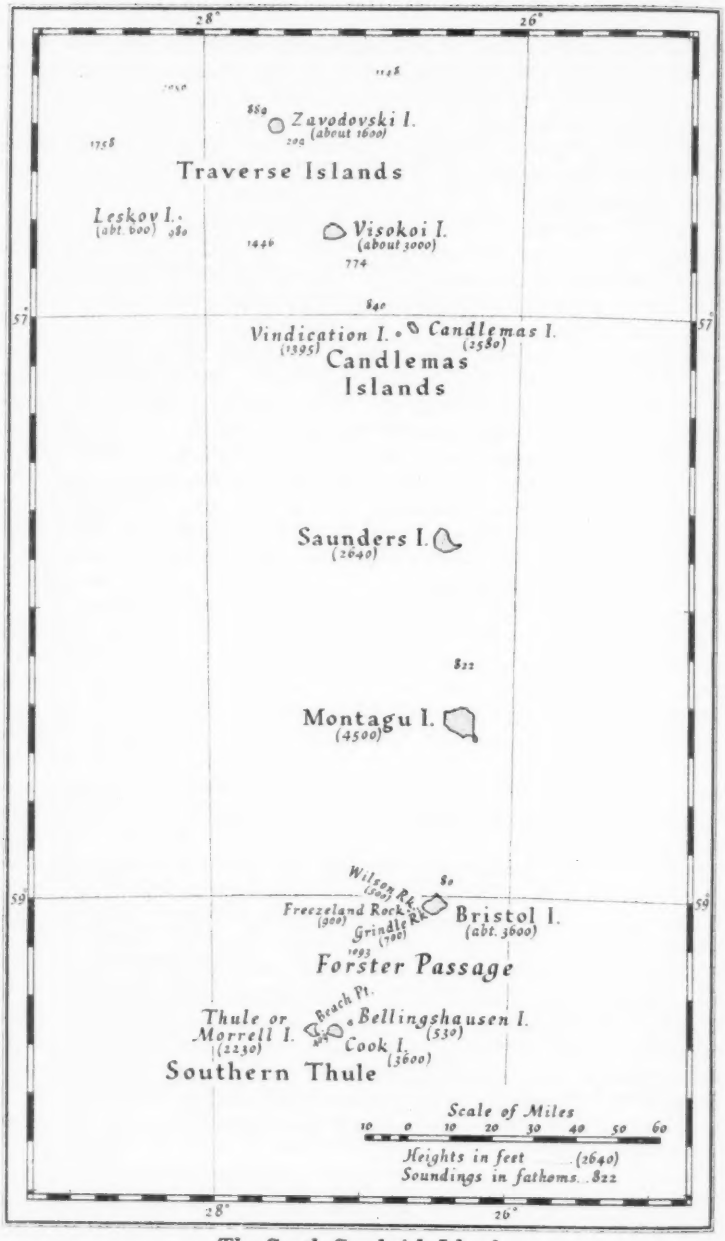
After Bellingshausen certain of the islands were visited in 1830 by Captain Brown in the schooner *Pacific* and by Biscoe in the brig *Thula*. Morrell relates that he examined all the islands in 1823, but his statements have often been proved untrustworthy, and his account, though extremely brief, contains several inaccuracies. Since 1830, so far as I have been able to ascertain, there is no record for seventy-five years of any visit to the islands, though it is practically certain that sealers must have gone there. In 1908 C. A. Larsen examined the group, seeking harbours and a site for a whaling station. In this he was unsuccessful, but he made rather considerable additions to our knowledge of the islands, though he missed one of them in a fog and by reason of pack-ice was unable to reach Southern Thule. He performed a remarkable feat—one which I think will not be repeated for many a long day—in landing on five islands. In going ashore on Zavodovski he was twice upset into ice-cold water, and on land was overcome by fumes, for the island still exhibits volcanic activity. As a result of this adventure he was seriously ill for some months. He collected geological specimens and trawled and dredged at a number of points.

In this summary of the history of the islands it is not possible to give a detailed account of more recent visits.† Filchner, on the Second German South Polar Expedition in 1911, examined the northern islands in very bad weather, and he gives some sketches of them in his book 'Zum Sechsten Erdteil.' In the same year some enterprising Norwegian whalers lost one of their vessels in heavy ice near Southern Thule. Shackleton sighted two islands from the *Endurance* in 1914, the *Quest* worked round Zavodovski in 1922, and the whale-catcher *Busen VII*, under Captain H. Hansen, visited the islands from Saunders northwards in 1927. In 1927/8 Mr. J. E. Hamilton, of the *Discovery* Committee's staff, accompanied the factory ship *Anglo-Norse* on a whaling expedition to the South Sandwich group, and he appears to have been the first to confirm Bellingshausen's statement that Southern Thule consists of three islands.

The South Sandwich Islands form a chain nearly 300 miles in length, and the positions which we assign to them bear testimony to the great accuracy of Cook and Bellingshausen. With modern instruments and wireless time signals little alteration has been made. The greatest discrepancy is in Visokoi, which Bellingshausen unaccountably placed some 8 miles north of its true position. The islands are all volcanic in origin, formed, it would seem, in tertiary times, and five of the eleven still show signs of activity, possessing

*Larsen's plans are unpublished. That made by the *Quest* is shown in *Rep. Geol. Collections made during the Voyage of the 'Quest' . . . in* 1921–2, p. 65 (British Museum, 1930).

†A fuller account will be found in Kemp and Nelson, "The South Sandwich Islands," *Discovery Reports*, vol. iii, pp. 133–198 (1931).



The South Sandwich Islands

craters or fumaroles which emit steam and vapour. Three others, according to our observations, appear to retain some warmth, while the remaining three are heavily glaciated, having an ice-cap with a probable thickness of some 200 feet in the southern part of the group. We made five attempts at landing, but by reason of the heavy swell and strong under-tow on the beaches all but one failed.

Zavodovski, the northernmost island, is nearly circular in outline and appears to have retained its original form better than most of the group. It consists of a simple volcanic cone, 1600 feet in height, resting upon a plateau of black columnar basalt, much eroded by the sea. Since westerly winds prevail abrasion is most active on that side of the island, while silt and lighter materials from the volcano are deposited in the east. Here, as in most of the islands, the steepest cliffs and deepest soundings are in the west.

Every one who has visited Zavodovski has remarked the strong sulphurous fumes emitted from the crater. Larsen, when he landed, found that "small stones were thrown a long way out of innumerable small holes in the ground, and that pure sulphur was flowing out of some cracks." Snow lies only on the eastern side of the cone, and on the plateau at its base there are large stretches of bare ground. The actual crater appears to have broken away, and it now lies on the western side of the summit.

Leskov seems to be a mere fragment of a cone, rising from comparatively deep water. It is the smallest of the islands, with a circumference of only 1½ miles. At the time of our visit it was covered with mist, and though this blew aside for brief periods we were not able to ascertain positively whether it retains any trace of volcanic activity. We think it must be extinct, but since it was not at all heavily glaciated, it is probable that it still retains some warmth. Leskov is about 600 feet high, and at its south-eastern corner there is a conspicuous conical rock 375 feet in height.

Visokoi is 4½ miles in length and everywhere, except at its eastern end, has precipitous sides. It is heavily glaciated, the glaciers reaching the sea, or hanging at the edges of steep cliffs. Brown described it as "a burning mountain," while Larsen says it is extinct. On a first visit we found a strong fumarole in a scree on the northern side, and later, sighting the island from some distance in clear weather, we were satisfied that steam was issuing from a crater near the summit. This is perhaps the highest island in the group, but there was too much mist for accurate observations.

From Visokoi we approached the Candlemas group, which was clearly visible. We were steering south and the land appeared, just as Cook had described it from the opposite point of the compass, as two hummocks on the horizon. Cook, on nearing the land, found that it "proved to be two isles. . . . A small rock was seen between them and perhaps there may be more; for the weather was so hazy that we soon lost sight of the islands and did not see them again until noon, at which time they bore West, distant three or four leagues." Bellingshausen however stated there were three islands, and gave positions for them. Larsen mentions one only, of which he made a sketch-plan. Filchner is quite emphatic on the point: there is only one island; but it is easy to make a mistake, as there are three summits standing on a single base—the circumference of the whole is 33 kilometres. This last statement seemed decisive, and as we approached the group we looked to find the low land connecting the

two hummocks. But they were very far apart, and as we got nearer it seemed more and more improbable that any connection could exist. Then we picked up a rock between them, then more rocks, and finally we learnt that the earliest description of all was also the most accurate. "Two isles . . . a small rock was found between them, and perhaps there may be more": exactly as Cook had said.

The smaller island is the only one in the group which has not hitherto had a name, and since there is already a Cook I., named by Bellingshausen, Captain Carey and I have suggested that Vindication Island would be suitable.

Nowhere in the group are harbours to be found, but there are several good anchorages in the Candlemas group. One in Southern Thule gives better shelter, but it is less useful as it will generally be packed up with ice.

Candlemas Island, about 3 miles long, consists of two parts. At the south-eastern end it reaches a height of 2580 feet and is buried deep in glacier. This end is presumably the site of the volcano to which the island owes its origin; but it is now extinct and the centre of activity seems to have shifted to the north-west. Here there is a low-lying plateau of basalt, quite bare of snow, from which rises the cone of a volcano 770 feet in height. It is dark red in colour with splashes of sulphur, and near it is another crater with its mouth little at all above sea-level. Wisps of steam and vapour were to be seen issuing in puffs at regular intervals and strong sulphurous fumes swept across us as we were making our survey.

Vindication Island is evidently warm; little snow rests upon it, and a stream —the only one seen in the group—runs down to the sea on its south-western side. It is 1395 feet in height, and like other warm islands is a favourite resort for penguins which have made large rookeries in its slightly hollowed centre.

Saunders Island has many features of interest. It is crescentic in shape, with a deep bay in the east guarded by outlying rocks and reefs. At its northern end is a volcanic cone, 2640 feet in height, which, though heavily glaciated, still shows most evident signs of activity. At the southern end is a range of completely bare hills, formed evidently of some soft material, such as volcanic ash, for they are cut into deep runnels by the melting snow. Of this island Bellingshausen has given a sketch, and since he shows a high cone on the southern range of hills it is to be assumed that considerable alterations have taken place during the past hundred years. These bare hills are evidently warm, but no indications of any volcanic activity were to be seen. To the north of them is a huge yawning crater, apparently extinct, and on the southern side part of another has broken away, leaving half a crater exposed to view in the cliff side. It is curious that this remarkable bisected crater has not been noticed before, for it is a most conspicuous feature, visible for many miles.

Montagu Island, with a length of 6½ miles and a circumference of 24 miles, is the largest island in the group. It reaches a height of 4500 feet, and with the possible exception of Visokoi is also the highest. It is heavily glaciated, and on the eastern side is bounded for 5 miles of its length by a vertical ice face, this being the longest uninterrupted glacier front in the islands. Montagu appears to be extinct, but at the base of a conical hill, 1660 feet in height and situated at its south-east corner, we thought we detected signs that some warmth still persisted.

Bristol Island, 5 miles long and 3600 feet high, is also heavily glaciated and is extinct. The glaciers are closely similar to those on Montagu, and we found that the height of the glacier face varied between 140 and 260 feet. The chief interest of Bristol Island lies in the three great rocky islets which lie to the westward. The outermost is Freezeland Peak, the first point that Cook sighted, and it is a magnificent rock, 900 feet in height with a lesser summit of 620 feet. Geologically it looks as if these three islets are the most interesting in the whole group, for if our view (unfortunately not based on any expert knowledge) is correct, it is here that the whole succession of formations in the islands can be observed. The great pillar of Freezeland is of a pale brown colour, different from anything seen elsewhere: it appeared to show signs of bedding, and we think it possible that it may be sedimentary. The lesser peak, obviously composed of eruptive material, is perhaps metamorphic. The next islet, Wilson Rock, is 500 feet high, and is composed throughout of black columnar basalt, here seen in much greater thickness than elsewhere. The inner islet, Grindle Rock, is 700 feet high, and is of the red andesitic and other lavas seen superposed upon the basalt in nearly all the islands of the group. It appears that the strata have been tilted, so that the rocks of the outermost islet are the earliest.

Southern Thule, as Bellingshausen stated, consists of three islands. Two of these, Cook and Thule, are buried deep in glacier, while the third, to which the name Bellingshausen Island has recently been given, still shows signs of activity.

Between Cook and Thule we discovered with our echo-sounding machines the existence of a very deep basin. The maximum sounding was 409 fathoms, and there is a comparatively large area with depths of over 300 fathoms. To the north and south the water is very shallow, with not more than 20 fathoms. We think it evident that this basin represents the original crater from which both Cook and Thule originated, and it is probable that the two were once joined together, forming one very large island. Here, as in Saunders Island and the Candlemas group, the centre of activity has shifted to a fresh site, and it appears likely that Bellingshausen Island is a more recent formation.

We found that the bottom of the basin between Cook and Thule was composed of black mud, smelling strongly of sulphuretted hydrogen, and few animals are able to live on it. The bottom layers of water are evidently stagnant, and our thermometer readings showed that they have the unusually low temperature of $-1{\cdot}63^{\circ}$ C. This is far lower than the bottom temperatures in neighbouring waters, and it is due to the fact that the basin is enclosed. In winter, and probably in most summers also, the strait is packed with ice, and the whole body of water beneath it becomes chilled by convection. When the ice clears away and circulation is restored, it is the upper layers only which are affected, the stagnant bottom water permanently retaining its low temperature.

Bellingshausen Island has a length of little more than a mile; but has a relatively enormous crater, from which, as well as from a fumarole, wisps of steam and vapour were seen to be rising. It has considerable stretches of bare ground and has numerous penguin rookeries. Cook Island is $3\frac{1}{2}$ miles long, with a peak of 3660 feet, and Thule $3\frac{1}{4}$ miles, with a height of 2230 feet. Both are very heavily glaciated.

It was at Beach Point at the north-east corner of Thule Island that we made our only landing. Here Dr. Marshall and Mr. Hart succeeded in getting ashore on a stony beach, bringing back information on the seals and penguins, samples of the meagre land flora, and geological specimens. Apart from the unicellular plant which forms the well-known "red snow," the vegetation seems to consist only of some lichens (which we saw on one or two occasions, but were unable to collect), and a green alga which Mr. G. Tandy has kindly identified as *Prasiola crispa*. This alga, though it forms a film only a fraction of a millimetre in thickness, grows luxuriantly in some places, especially on penguin rookeries, and it no doubt accounts for Cook's remark that one of the islands "seemed to be covered with green turf." Professor G. W. Tyrrell has kindly examined the geological specimens, and he has reached the important conclusion that they are typical Andean lavas.

From this brief summary of our work at the South Sandwich Islands it will be seen that a good deal of new information has been acquired; but it will be obvious that much more remains to be done. In geology, especially if landings could be effected, most interesting results might be obtained: an expert in physiography might discover valuable clues to the past history of the group; the flora, birds and seals require further investigation, and notwithstanding our trawlings and dredgings the marine fauna with its great wealth of animal life is still largely unknown.

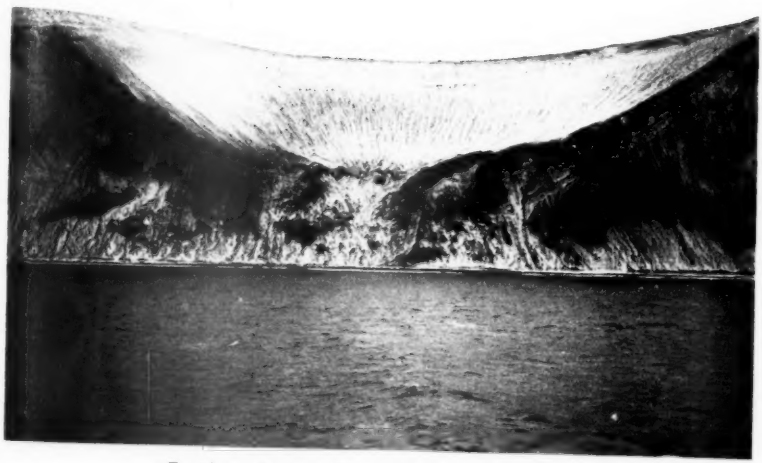
At the time of our visit to the islands our shallow-water echo-sounding machine was working admirably, and inshore soundings, which from a navigational view are of greatest importance, were taken in large numbers. But the deep-water machine was not efficient over the whole of its range, and we were thus unable to sound out the bank on which the islands stand with any degree of thoroughness. Fortunately we were able to get expert assistance when we underwent a refit in South Africa, and in the following season, 1930/31, we were able to gather some interesting data bearing upon the topography of the sea-bottom in this part of the Southern Ocean.

It was Nordenskiöld who first showed that the volcanic rocks of Graham Land are identical with those of the Andes, and Suess put forward the theory that there was a protrusion of these Andean types far into the Atlantic, and that a former land connection existed through Cape Horn, the Burdwood Bank, South Georgia, the South Sandwich Islands, the South Orkneys, and the South Shetlands. This is known as the theory of the South Antillean Arc,* and though it has been contested on geological grounds, opinion nowadays is mostly in its favour. It is strongly supported by the conclusions which Professor Tyrrell has drawn from our specimens from Thule Island. Soundings throughout the area are very scanty, but a few of them seemed to show that ridges connecting the islands might be found. This material has been seized upon by supporters of Suess's theory for the construction of contoured charts; but these, since they are based on inadequate data, are in reality little more than an expression of the personal views of the author.

During the past season, with our deep-water echo-sounding apparatus working well, we have taken every opportunity to obtain soundings between

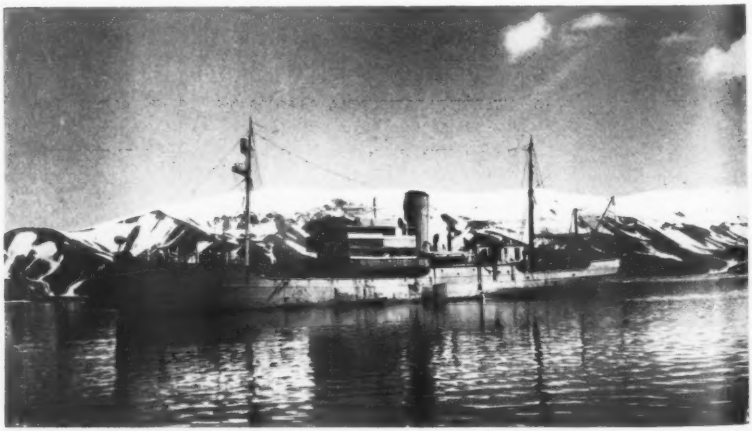
*The term "South Sandwich Arc" is perhaps to be preferred, since it does not suggest a misleading comparison.

Bristol Island, north-eastern side



Section of exposed crater, Saunders Island

Two views of a tabular berg; in the lower an optical illusion causes the flat sunlit surfaces to appear as hollows



Discovery II at Deception Island

the island groups. Sounding continuously, day and night, whenever we were at sea, we have in one season taken more soundings than previously existed in the whole area, and we have been able to show that some of the links in the chain that Suess postulated are very well defined.

Between the Burdwood Bank and the Shag Rocks we have only one line, but it was taken on a zigzag course across the area where we hoped to find the ridge. The soundings are insufficient for contouring, but none the less give good indications that such a ridge is to be found. To the north and to the south there is over 2000 fathoms, and on our course we have 41 soundings of under 1000 fathoms, 21 under 500 fathoms, and 4 under 250 fathoms. The lowest sounding is 201 fathoms situated about midway between the Burdwood Bank and the Shag Rocks. Between the Shag Rocks and South Georgia four lines of soundings show the existence of the ridge very clearly, and farther to the east a connection with less than 2000 fathoms has been shown to extend to the South Sandwich group.

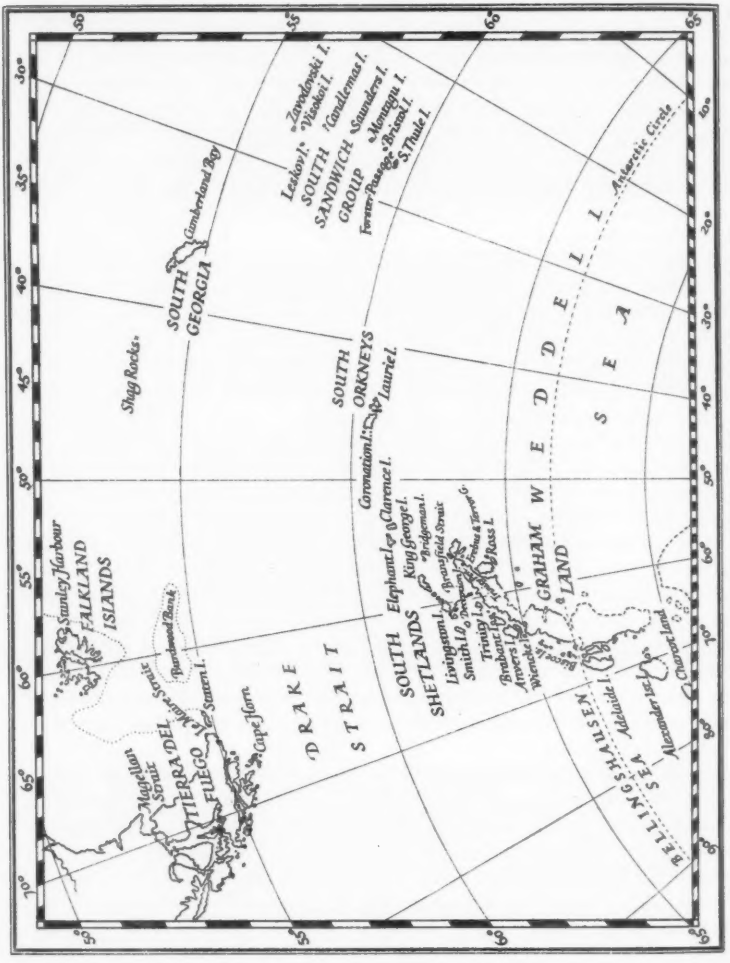
North of the South Sandwich Islands the *Meteor* obtained a sounding of 4402 fathoms—at that time the deepest point in the whole of the South Atlantic. We ourselves recorded soundings of over 4000 fathoms near this position, and later, on a course running east-north-east between Saunders Island and the Candlemas group and thence in a north-west direction, we made two traverses of the deep, which is thus shown to exist far to the south of the point at which it was originally discovered. It has the form of a curved trough lying just to the east of the island chain, and its breadth abreast of the Candlemas group is only some 20 miles. The southern limits of the deep yet remain to be traced. The greatest sounding we obtained—4421 fathoms (fully corrected)—is only slightly in excess of that recorded by the *Meteor*.

We have not so far been able to search for a connection between the South Sandwich Islands and the South Orkneys, for last season the whole of the area was packed with ice. In this long distance there are at present only a few soundings, taken by the *Scotia* and the *Deutschland*, which indicate the possibility that a connecting ridge exists. Between the South Orkneys and the Elephant group we have made several traverses and the connecting ridge is very sharply marked. The slope of the bottom is in some places remarkably steep, at one point lying at an angle of about 45°, and for part at least of its length the ridge is double.

I hope that during the present commission of the *Discovery II* we shall be able to obtain more data on this subject and fill up some of the gaps which at present exist in our knowledge. Apart from their topographical interest these soundings are of importance geologically, and they are also of considerable value in our special work on oceanography. For, like the Wyville Thomson ridge in the North-East Atlantic, different hydrological conditions are found on either side of them, and some at least separate water masses of widely different origin.

In October 1930, on our return to South Georgia from Cape Town, we paid a visit to Bouvet Island and, as several vessels before us have done, we made search once more for Thompson Island and the rocks called the Chimneys, which Norris in 1825 reported as lying 45 miles north-east of Bouvet. We had clear weather, but a big sea was running and echo-soundings were unusually

difficult to obtain. We quartered the locality thoroughly, examining some 6000 square miles of sea, and no trace of the island was to be found. In this region there is an extensive area with less than 1000 fathoms of water; but it seems that we have traced out the approximate boundaries of this rise, and in the area examined it is certain that no island exists.



General Map of the Falkland Islands and Dependencies

Thompson Island thus remains a mystery. Norris's account is so circumstantial that it is impossible to disbelieve it altogether, and the only possibilities seem to be (i) that Norris mistook morainic bergs for islands; (ii) that his bearings are completely misleading; and (iii) that the island once existed and has since disappeared. My own personal view is that the morainic berg theory

is the least improbable, for these black bergs can in certain conditions bear a very close resemblance to rocks and islands. A shallow sounding would disprove this theory at once, but Norris took no soundings near Thompson Island.

Of Bouvet Island itself running surveys had previously been made by the *Valdivia* and *Norvegia*, but on plotting positions we found a lack of agreement, and we therefore made a fresh survey, taking two lines of echo-soundings round the island. We searched in vain for a pyramidal rock said to lie 5½ miles off the coast.

That Norris did not take any soundings near Thompson Island is perhaps excusable: a hundred years ago a captain operating in these waters must have been very fully occupied in navigating his small vessel. There seems however to be less excuse for vessels which in recent years have reported dangers to navigation in the Southern Ocean. On this subject I write with some feeling, for in the aggregate we have spent whole days, often diverging widely from our proper course, in trying to rediscover these perils. Vessels light-heartedly report rocks, reefs, or breakers in the open ocean, growing kelp is observed, people lean over the side and actually see the bottom—and we go there and find 2000 to 3000 fathoms of water. In a number of cases we have succeeded in producing sufficient evidence to persuade the Admiralty, and the charts have been corrected; but for obvious reasons it is far easier to get a rock inserted on the charts than to get it expunged. If only those who make reports would remember the elementary use of the hand-line and lead, they would save much time and trouble to those who come after.

At South Georgia last season some survey was undertaken in continuation of the more detailed work done by Lieut.-Comdr. Chaplin. New fixes were obtained for the Willis Islands, which on the old charts were placed much too far to the west, and a running survey was made of the approaches to Undine Harbour. On December 2, one of those very rare days at South Georgia when the weather was quite perfect, we ran along the whole length of the south-western coast, obtaining a line of soundings and new fixes of the outlying headlands and islands. Even from the approaches to Undine it was evident that something was seriously amiss, for Green Island and Annenkov, which should have been shut out from view by Cape Nunez, were both clearly visible. We found it was Cape Nunez which had been wrongly charted, lying 6½ miles south-west of its true position. On this occasion we were only able to correct the positions of the headlands: the bays were not examined and there is much further work to be done.

We hoped during the past season to carry out surveys in the South Orkneys; but on visiting them in the middle of December we found that pack-ice extended at least 20 miles north of the group. Later, in February of this year, we rearranged our programme in order to make a second attempt, but this too failed owing to ice and weather. On our arrival we found that ice lay to the east of Signy Island, and we anchored in Sandefjord Harbour in Coronation Island. Here we remained five days, hoping to obtain sights of sun or stars, but though continuous watch was kept no opportunity occurred during the whole period. We left with ice drifting into the harbour and with a strong ice-blink to the southward. Shortly afterwards it cleared for a brief time and we were able to fix the western end of Coronation Island and some outlying rocks.

General Map of the Falkland Islands and Dependencies

It had not been our intention to attempt surveys in the South Shetlands, but this work is so entirely dependent on weather conditions that it is essential to seize on every favourable opportunity. While we were carrying out our scientific programme in the Bransfield Strait at the end of December we happened to have a few days of exceptional weather, and these we tried to turn to good account by re-fixing the positions of some of the islands and rectifying parts of the coast-line. The work was continued in February on our return from the Bellingshausen Sea, but only a small portion has as yet been completed.

The charts of the South Shetlands are based largely on work done nearly one hundred years ago, and they are known to be inaccurate in a number of particulars. We have found that several of the islands were widely out of position, reefs known to the whalers but not hitherto charted have been inserted, and large corrections have been made in the vicinity of Snow and Livingston Islands. An intricate passage between these islands has been surveyed, and it is believed that this will be of value to whalers working from Deception Island. Many lines of echo-soundings have been taken in Bransfield Strait, and the bottom topography, with its two enclosed basins, is now known in general outline.

In January and February 1931 we made a passage to the Bellingshausen Sea, but ice conditions were against us, and when we reached Adelaide Island we found it invested with pack-ice and we could not get near Stefansson Channel, where we had hoped to verify some of the discoveries made by Sir Hubert Wilkins. Alexander I. Land was clearly seen across some 40 miles of pack, but we did not sight Charcot Land. We skirted the pack to the west, hoping to find an opening; but in this we were unsuccessful, and in long. 101° W. we turned south and forced our way through it. In lat. 69° 49½′ S. we were held up by floes at least 20 feet thick, and had to retrace our steps. We were then at least 250 miles, and perhaps very much more, from the unknown land which lies somewhere to the south, and soundings of over 2000 fathoms showed that we had not reached the continental shelf.

Here, in the Bellingshausen Sea, the difficulties attending geographical exploration appear to be unusually great. From what we can gather from previous work in the area, and from our own experience, the pack does not set away from the coast in a normal year. There appears to be no clear water behind it, and we found it closely impacted and without the open leads which afford so much assistance in navigation. I believe myself that in average seasons a vessel will have to penetrate several hundred miles of very difficult ice before reaching the coast. Fortunately, seasons vary greatly, and apart from work by aeroplane, the best hope of success seems to lie in a determined attack made in a year when the ice is exceptionally light.

All the icebergs seen in the Bellingshausen Sea are low and of comparatively small size, and from this it may be inferred that there is no barrier in any way comparable with those formed in the Weddell Sea and Ross Sea.

Returning on our tracks we sighted Peter I. Island, and on reaching Adelaide Island found that the pack-ice had set down to the south-west. Stefansson Channel was still blocked, but our navigating officer was able to confirm the positions given by Charcot for the peaks on Adelaide Island. From here we took a line of observations in plankton and hydrology extending far to the

Weathered berg, showing old water-levels

Cape Errera, Wiencke Island

Looking across Neumayer Channel to Mt. Français, Antwerp Island

Looking across Neumayer Channel to Mt. Français, Antarctic Peninsula

north-west, finding in the course of the work that the continental shelf extends to a distance of 80 miles from the coast. At about 30 miles from the coast soundings of 300–368 fathoms were found; beyond that less than 300, until at the edge of the shelf there is a sudden drop to 1200 fathoms.

When this work was completed we entered Matha Bay and visited the Marin Darbel Islands and the Biscoe Archipelago. This is a most difficult and dangerous coast; it abounds in uncharted reefs and islands, and soundings alter with a rapidity which is sometimes almost alarming. To survey this area must necessarily take a very long time, and it would inevitably mean much boat work. On the occasion of our visit there were innumerable bergs among the islands, and to distinguish one from the other was often a matter of the greatest difficulty. Sometimes bergs could be recognized by their angular outline, but very often they were rounded. Sometimes islands could be distinguished by a bluff of bare rock; but often they were completely glaciated, and apart from soundings, the only way to tell them was by the black line 2 to 3 feet wide at the water's edge, where the ice had been undercut back to the rock by tidal action. This indication was, of course, useless at high water. In the Marin Darbel Islands we found and surveyed a small harbour. It was well sheltered from wind and sea, but could scarcely be a comfortable spot by reason of the high ice-cliffs which surround it.

Passing north-east we came up with Cape Bellue, and this, according to Sir Hubert Wilkins's sketch-chart,* should be situated on an island, with an entrance to Crane Channel, leading to the Weddell Sea, on either side of it. We searched the coast closely as we passed slowly along, in an attempt to find these channels, but high land is continuous on either side of Cape Bellue, and no trace of them was to be seen. Crane Channel was discovered by Sir Hubert Wilkins when flying along the western side of the Weddell Sea. In his chart the two entrances from the Bellingshausen Sea are merely indicated by running dots, and it may be supposed that he was by no means certain of them. Our observations do not disprove the existence of Crane Channel; they merely indicate that its western approaches do not conform with Wilkins's chart. There is still a possibility that a through channel exists, reaching Bellingshausen Sea farther down to the south-west.

We passed through Pendleton Strait and returned through Bismarck Strait, which was almost blocked by innumerable icebergs, to Port Lockroy. Here ice drifted in on us and it was some days before we could get clear and continue our way through Neumayer Channel and De Gerlache Strait. In the Palmer Archipelago, thanks to the work of the *Belgica* and of the French expeditions under Charcot, the charts are more accurate than in the South Shetlands: a few minor corrections were made as we passed through the islands and a series of soundings was taken in the channels.

In our visit to the Bellingshausen Sea the amount of survey work actually accomplished was little, but in other ways we obtained very interesting results and echo-soundings were taken continuously. We have gained a good knowledge of the difficulties likely to be found, and this will stand us in good stead in the future.

**Geographical Review*, vol. xx, no. 3, July 1930.

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: Oceanography is perhaps not always given by the general public the attention that it deserves, for oceanography is a subject of very great interest. The depths of the sea are no less interesting than the heights of the mountains. Those of us who were so fortunate as to hear the lecture Dr. Kemp gave before Section E of the British Association last September will have heard of the geological and biological researches successfully undertaken and of the investigation of kindred subjects which was carried out by the *Discovery II* Expedition. To-night Dr. Kemp will tell us of the surveys and of the soundings. An immense deal of sea was covered during the period of rather less than two years when the expedition was in the South: a period of real good hard methodical work. It may be that such work is not so spectacular as that of other expeditions, but the results which they have brought back are of very great value indeed. Dr. Kemp is a graduate of Trinity College, Dublin. He was Assistant Naturalist in the Department of Agriculture and Technical Instruction for Ireland (Fisheries Branch) from 1903–09, and was Superintendent of the Geological Section of the Indian Museum at Calcutta for fourteen years. And since 1924 he has been a director of the scientific exploration of the Antarctic, concerned mainly with whaling, and particularly on behalf of the Government of the Dependencies of the Falkland Islands, for the *Discovery* Committee. It is of the surveys and soundings of that expedition that he will give us some description.

Dr. Kemp then read the paper printed above, and a discussion followed.

Dr. H. R. MILL: It is with very great pleasure, I am sure, that we have all listened to this account of the survey work of the *Discovery II*. The expedition has been known mainly for its biological and economic work in the study of whales and their habitat. I must confess that from some of the early reports of the work of the ships of the *Discovery* Committee in the Antarctic I had begun to feel a suspicion that they had not paid much attention to geographical work. That suspicion has been entirely dissipated by the paper we have listened to this evening. The difficulty of surveying in those regions has been recognized from earliest times and the variety of the conclusions drawn by apparently trustworthy observers is one of the most entertaining diversions in the study of Antarctic history.

I have always felt that an Antarctic explorer should be left with unfettered powers of altering the plans laid down for him by the authorities at home, because there are occasionally unforeseen opportunities which if taken advantage of may enable one in a single week to do work which might otherwise take years to accomplish by special expeditions sent out for that work only in ignorance of the conditions prevailing. The admirable charts that have been made of the South Sandwich group confirm my view that the greatest care should be taken in the choice of Antarctic explorers and then that the utmost freedom should be left to them.

The beautiful photographs that were shown impress one with the idea that long ago there was far less of permanent interest to be derived from the observations of travellers than is the case now. But there is another side to this consideration. The attraction of unknown regions has often been increased by the remarkable nature of travellers' tales, and while we appreciated to-night how extremely accurate were the surveys and how very cautious the conclusions arrived at by that gallant navigator Captain Cook, we need not forget that it was not always the same when his subordinates gave a description of what they saw. I can show the lantern slide of a picture published in the first account of Cook's

Voyage, an account written by the gunner's mate of the *Resolution*, surreptitiously published, which described the mountains of South Sandwich Land, the true views of which Dr. Kemp has shown us. This was one of the mountains which Cook said seemed to be lost in the clouds. Perhaps the gunner's mate had access to the log of one of the navigating officers and found that this mountain rose 17 feet above the horizon, and took the minutes of arc measured with the quadrant as minutes of latitude or sea miles, and so he said the mountain was 17 miles high and the artist nobly strove to represent it with the result you see!

I shall say no more beyond expressing my great pleasure in having the results put forward so quietly, so thoroughly, and so convincingly by Dr. Kemp; and I am sure we all feel that the *Discovery II* has worthily added fresh lustre to the name of her predecessors, the *Discovery* of Scott, the older *Discovery* of Nares, the yet older *Discovery* of Cook's third voyage, and the oldest *Discovery* of Baffin.

THE HYDROGRAPHER OF THE NAVY (Vice-Admiral H. P. DOUGLAS): As a surveyor I have followed the lecture with considerable interest and should like to place on record my opinion that the officers of *Discovery II* carried out their work in a most creditable manner, more especially when you take into consideration the hard time which they had and the very great difficulties with which they had to contend. Though, as the lecturer said, what he called a running survey is one of the least accurate, it is at the same time one of the most difficult to carry out; that is, if you hope to obtain good results. I am quite sure from what I have seen and the conversations I have had with Sub-Lieutenant Nelson, who did the major portion of the work, that he has done his work most conscientiously, thoroughly, and must unremittingly have kept at it the whole time.

It is a cause of great satisfaction to me to know that the Admiralty echo-sounding apparatus has proved so accurate and so good; to have obtained a sounding of 4400 fathoms, I think, speaks well for it, especially as it is a comparatively new invention. I think great credit is due not only to the machine but also to the officer who took the soundings, because he has a most wonderful sense of hearing! Mr. Herdman, the officer I refer to, really did most useful work.

The only other point I would like to make is to support heartily the lecturer's remarks regarding the reports of dangers we receive. Time and again at the Admiralty we receive reports of breakers, shoals, fish jumping out of the water, birds flying over reefs, and never any attempt made to verify these reports by soundings. As the lecturer has pointed out, it is very difficult for us to discredit such reports. At the same time, you do not want to plaster your charts with all sorts of what we call vigias which must be of great anxiety to the sailor next time he passes near such a reported danger. So I hope now, with the arrival of echo-sounding, which is a much easier way of taking soundings, we shall be able to have more authentic details before these dangers are reported.

There is one result of the work of the *Discovery II* which the lecturer did not mention explicitly, with regard to that lost group of islands, Thompson's Island and the Chimneys. From old records we seem to have lost them ever since Norris sighted them, so it was with very great pleasure we were able on the survey of *Discovery II*, coupled with all the old searches made for these rocks, to expunge them from the charts as being non-existent.

The PRESIDENT: Mr. Wordie's knowledge of the southern part of the Antarctic Ocean is such that I am sure we should like him to add a word or two.

Mr. J. M. WORDIE: Dr. Kemp has raised some most interesting points to-night, but there is very little time in which to discuss them. Perhaps the most interesting feature however of the whole expedition is the verification which the soundings have given to the supposed Island Arc stretching from South America round through the South Sandwich group and into Graham Land. Already

before the *Discovery II* sailed, geologists were nearly all agreed that an arc existed; it is true there were still a few doubters. When the charts, which Dr. Kemp has shown to-night, are examined even doubters will now be convinced. It only remains to plot further details of the connection, and to confirm that there is not one arc but a series of concentric arcs linking the two continents of Antarctica and South America. This will no doubt be done by *Discovery II* on future voyages; at the present time she is in fact once more in the Antarctic near South Georgia, and we hope that her second commission may be as brilliantly successful as her first.

The PRESIDENT: I would like to emphasize two things in Dr. Kemp's lecture: one, the astonishing accuracy of Captain Cook's surveys, and the other, the great advantage to be gained by the accuracy of the most modern ways of taking soundings, namely, echo-sounding. You have heard the Hydrographer sympathize with Dr. Kemp on the subject of the reporting of vigias. Professionally, I should like to add my sympathy with them both. Having from time to time searched for some of these hidden dangers that do not exist, I feel the greatest sympathy with them. I may however tell both my brother officers and Dr. Kemp, who is almost a brother officer by reason of the amount of sea work he has done, that the reported dangers on shore are infinitely greater in number than those at sea!

It is not only Antarctic explorers who want to be left alone. All explorers who are worth their salt, once they have started off, should be left to make their own moves on their own responsibility, and the Fellows of this Society may be quite certain that that is the line which is followed by this Society when they send people out or encourage them to go out on exploration.

I hope that Dr. Mill is right about the gunner's mate and why he made mountains 17 miles high. From my knowledge of gunners' mates, and it is considerable, I rather expect that he thought it was a matter of loyalty to his own expedition: he thought that, at any rate, his own captain would not be beaten. But please do not think I am being flippant about these matters. I want to express to you, Dr. Kemp, our very sincere thanks for your lecture and also our great admiration of this admirable and exceptionally thorough work. As one looks at all you have done one feels that there is nothing left out. It is admirable. I offer you, on behalf of this audience and on behalf of the Society, our very sincere thanks.

Professor J. W. GREGORY, *who was unable to be present at the meeting, sends the following contribution to the discussion:*

I much regret that I was unable to be present at Dr. Kemp's lecture to congratulate him personally on his important contribution to the geography of the South Sandwich–South Georgia region. Dr. Tyrrell's determination of the rocks collected by Dr. Kemp on the South Sandwich Islands as Andean lavas is a valuable advance in the settlement of the South Georgia problem. Dr. Tyrrell's identification appears at first sight to support Suess's interpretation of South Georgia as part of an Andean loop; but it appears to me to confirm the alternative explanation, as it emphasizes the absence of the Andean igneous rocks from South Georgia. The occurrence of the Andean rocks in Graham Land and their discovery by Dr. Kemp in the South Sandwich Islands indicate that the Andean line continues southward from Patagonia to Graham Land and then turns eastward to the South Sandwich Islands instead of making a horseshoe bend through South Georgia and through the south Sandwich Islands back to Graham Land. The Andean volcanic belt throughout South America lies along the border of an ancient continental mass; and after study

of Mr. D. Ferguson's collection from South Georgia, I suggested that that island was part of this continent and not part of an Andean fold mountain loop. Dr. Kemp's collection is consistent with that suggestion, and indicates that the Andean volcanic belt is continued along a line that passes hundreds of miles south of South Georgia.

As reference has been made to the corresponding Antillean loop of Suess, I may remark that, after repeated inquiries in various directions, I have at length, thanks to Dr. C. A. Matley, gained access to an extensive series of records of strikes of the rocks in Barbados. These strikes confirm the suggestion made from the scanty records on Jukes-Browne and Harrison's map of Barbados, that that island is not part of an Andean loop but part of a belt folded by pressure from the south and nearly at right angles to the trend required by Suess's interpretation of the Lesser Antilles as an Andean loop projecting with the Atlantic. This new evidence from Barbados and Dr. Tyrrell's determination of the South Sandwich lavas strengthen the objections to both of Suess's Antillean loops.

THE BASIN OF THE RIVER PARANA: *Continuation from the February Journal of a paper read at the Evening Meeting of the Society on 16 November 1931, by*

W. S. BARCLAY

Posadas to Iguazu

From Posadas it is a 31-mile motor drive to the Jesuit ruins of San Ignacio. These may be taken as a fair example of the many Jesuit "Reductions" established both in Misiones and in southern Paraguay, after their historic exodus from Guayra, where they had extensive settlements on the banks of the River Piquiry, which flows into the eastern shore of Guayra lake. The Jesuit coat-of-arms is still visible on one of the stones of the church at San Ignacio.*

The latest addition of the Argentine Navigation (Mihanovich) Company to their Alto Parana service is the "Guayra" oil-burning motor boat, Glasgow built, and capable of 15 knots. The greater margin of speed upstream, afforded by oil fuel, enables the round trip from Posadas to Port Aguirre (Iguazu) to be made in forty-eight hours. The change from the treeless Pampa to this rocky forested country, confining a swiftly flowing river, which opens up ever-changing vistas of sub-tropical vegetation, with squatters' cabins, and timber or yerba maté shoots descending from high bluffs on either shore, never fail to strike the Argentine citizen, who for the first time visits this portion of his extensive patrimony.

Leaving Posadas at 7 a.m. we arrived at Port Aguirre by 11 a.m. next day. The river, which in this month should have been falling, was about half-flood, *i.e.* one-half the yearly average high level calculated from a low-water zero, as is the custom at all river ports. Twenty days' heavy local rain doubtless accounted partly for the rise, but the Parana draws its volume from such distances that a local rise and fall often bears no relation to local rainfall. During the year of the great flood in 1905 the rainfall at Iguazu Falls was only 2·61 metres compared with an average 2 metres, but on the Brazilian coast was over 7 metres. The day before our arrival the river had washed away 20 feet of the muddy bank in which were cut the steps leading down to a Mihanovich steamboat that served as a combined landing-stage and hotel. The 20 kilometers motor road to the falls is graded, and for the past ten years an hotel of about fifty beds has been open near the Argentine Falls. On the opposite Brazilian bank, at a higher level, stands a large structure also intended for an hotel, but still unfinished.

The Iguazu river forms part of the Argentine–Brazilian frontier for 115 kilometres from its mouth, and in consequence some difficulty is liable to arise in obtaining proper facilities for sightseeing on both banks, since strict formalities are now exacted from all travellers entering and leaving these countries at any point. One of the first steps towards placing the Iguazu and Guayra Falls on an equality with other world attractions must be the co-opera-

*The previous abandoned state of these ruins was brought to the notice of the Argentine authorities after a trip to the Iguazu Falls in November 1901, when the author accompanied Mr. Follett Holt and Mr. Henry Darbishire. It is a pleasure to record that their historical value is now fully recognized and proper caretakers provided.

tion of the Argentine, Brazilian, and Paraguayan authorities, whether State or Municipal, to mutually facilitate entry to the best view-points. The Iguazu Falls have by now been so often described that one hesitates to add further impressions. The visitors' book at the hotel a year ago recorded a growth from 97 guests in 1921 to 1050 in 1930. The majority of visitors are foreign, *i.e.* not Argentine or Brazilian, and their invariable tendency is to compare the Falls of Iguazu with Niagara, ignoring their completely different origin, surroundings, and climate. But this may be said, after exploring the multitude of joint or separate falls at Iguazu, which ring its circumference for 2½ miles, with the sub-tropical forest forming a natural background and conservatory—that one can with difficulty recall any similar spectacle at once so varied and so beautiful.

Misiones territory is being rapidly opened up by Argentine colonization, in which respect it is in marked contrast to the remainder of the Alto Parana shores, whether in Paraguay or Brazil. If a stay at any of these colonies is not feasible, the visitor would do well to arrange for a call at Port Bertoni, lying some 10 kilometres downstream from the mouth of the Iguazu river, on the Paraguayan shore. The station is named after the well-known Italian scientist who for over thirty years made this a centre for his collections of the flora and fauna peculiar to the Alto Parana regions. Information regarding these collections can be obtained from the La Plata Museum, close to Buenos Aires, with which he was in constant correspondence. A museum with many specimens of value still stands in Port Bertoni, but the chief attraction will be found in the arboretum and grounds of much interest and beauty. The information which can be gathered there will add greatly to the pleasure most travellers find in trips through the forest.

On our return to Port Aguirre we obtained from an Argentine doctor some details of the local epidemic of malaria, on this stretch of the river, which he had been sent to combat. He calculated that in Misiones alone 15,000 patients were at that time simultaneously affected. Flood and rain over so large an area made it impossible, in his opinion, to eradicate the infection-bearing mosquito, the only alternative being to distribute quinine and good advice. The latter he delivered in fluent Guarani, the *lingua franca* of all river workers, which counted as not least of his many qualifications. The epidemic in Misiones he attributed to infection brought by workers from the river above Guayra, where a similar outbreak had taken place the previous year. The disease will now probably become endemic throughout the whole Alto Parana valley, though not, in our informant's opinion, seriously so. As regards passing travellers, this assumption is probably correct, for in the four weeks of our river voyaging I cannot recall any evening or night on the river boats when insects from the shore, or mosquitoes, came on board and we slept without mosquito-nets throughout. Sleeping on shore however is a different matter, and nets should everywhere be used.

It is possible to approach to within 2000 yards of the falls by motor boat if the Iguazu is low, but when the Parana has risen, the Iguazu becomes slack enough to permit of approach by canoe. In other words, the rise and fall on the main river is so great as to have a tidal effect on its tributaries. About 8 kilometres below the big fall can be seen the fall of the São Joao stream, and, farther down, that of the Tarmandua.

The annual rises on the Alto Parana take place steadily and rapidly over a period of about two months. The decline of flood water, on the other hand, is more gradual and intermittent, lasting three to four months, till the low-water level is reached, usually during the cold season, *i.e.* April to August. The difference in time between the periods of rise and fall is due to the regulating action of the dense forests which cover both shores throughout the valley. After reaching saturation point from heavy rain, these discharge their surplus waters quickly in the flood period, but take a much longer time to drain out. Factors however which affect flood water on the Parana at any point are extremely complex, and local rises and falls of 10 to 20 feet within twenty-four hours anywhere below Guayra are common.

Side-falls on the Parana when approaching Iguazu prepare one for their reappearance in the remaining reaches to Guayra. Between Port Aguirre and Port Mendes eight or nine considerable side-falls may be seen from the steamer's deck on the Brazilian, with an equal number on the Paraguayan, shore. In addition, many streams entering the Parana on either hand conceal a fall at short distance from their mouths. These side-falls vary from 50 to 150 feet, their height increasing upstream with that of the basalt cliffs which hem in the river, and to which they are due. Three kilometres beyond Port Mendes is another very beautiful "São Joao" fall of 210 feet height, enclosed in a hidden gorge which bends at right angles before entering the main river. Having expressed a wish to view it, I was told that the path was now overgrown, as for some years no one had troubled to go there! These minor falls, viewed in every variety of setting, constitute an attraction which, if perhaps not equal, is an amazing supplement to the two major falls. The vegetation surrounding them, bathed by continuous spray, constitutes a specialized addition to the sub-tropical forest. Another unexpected sight on the river approaching Guayra are the whirlpools, which steadily grow in size and strength with the swifter currents of the river. These whirlpools range from 100 feet in diameter to the size of a hat, and the whole surface of the river is pock-marked with them, whirling in obedience to forces hidden far below, while the steamer battles bravely with their efforts to pluck her off the course.

Port Mendes to Port Epitacio

Landing facilities at Port Mendes consist of the usual inclined ropeway, which runs to the top of the cliff at a height of 90 metres (say, 300 feet) above low-water. A barge acts as landing-stage, the port being on the Brazilian (Parana) shore. The top of the rope incline is also the lower terminal of the Matté Larangeira Railway. I was told that in the early days of working the southern Matto Grosso yerba groves the Company carted all their produce to Paraguay river, employing in their carts 36,000 bullocks, one-half being at work and the remainder at pasture. Last season (1930) the Company shipped 11,000 tons of yerba down the present railway, *via* the Alto Parana route to Buenos Aires. Owing to the protective quota recently imposed by Argentina, their shipments may now drop in proportion. None the less, the yerba maté trade from Guayra is still the foundation of the present excellent travel facilities on the Alto Parana as far as Port Mendes. If this traffic is further seriously curtailed, the steamer service, failing any new developments, will

Head of the Guayra Gorge (6 on plan)

Gorge of Guayra: Rock and Falls 11 and 12

Gorge of Guayra: Rock and Falls 11 and 12

necessarily be curtailed also. It seems therefore in the interests of the public, as well as of those concerned in the yerba business, that the tourist traffic should be fostered as a supplement to the present purely trading connection.

The Matté Larangeira Railway from this limit of navigation below Guayra is of narrow, *i.e.* 2-foot 6-inch gauge, with a length of 59 kilometres to its present terminal Villa Guayra, situated on the bank of Guayra Lake, directly opposite the head-falls. The journey takes two hours by train and half an hour less with a petrol rail-car. There are five halts, chiefly to serve timber mills *en route*, but as the line runs roughly parallel to the river, it is possible by "picadas" cut through the forest to intercept the gorge at various points. No survey of the full length has yet been made; but its length was given to me as covering about 12 miles from the head-falls.

Villa Guayra has a population of about nine hundred people, all workers or dependants of the Matté Larangeira Company. The Company employs a further two thousand men in forest work, the centre for which is Campanario, on the Matto Grosso side. The best yerba is not found amongst heavy forest but on the fringe of the bush country round the head-waters of the Amambahy range. The little town at Guayra has been carefully laid out, with school, hospital, drainage, telephone, water and electric light service, and other amenities of civilized life which one hardly expects to find in one of the remotest settlements of Brazil. In the main avenue stands an hotel, or more properly, guest-house, which accommodates about twelve guests, but whose kitchens serve about fifty additional households daily with full *en pension* meals. In short, the general accommodation at Guayra is much in advance of that at Iguazu, but it is at present only provided by courtesy of the Matté Larangeira Company, which owns the whole town site as well as the railway.

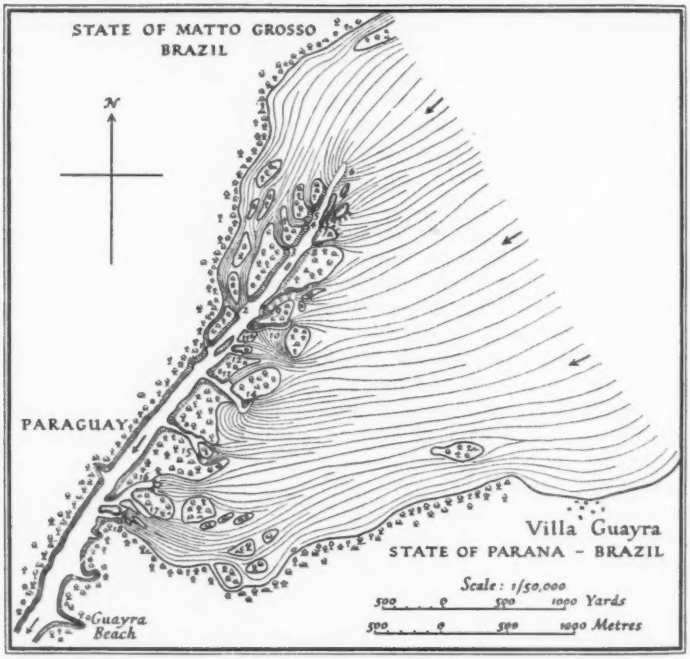
Facilities for travel on the run to Port Epitacio upstream are also provided by the Company, which has within the last year placed on this run a special steam launch, housing crew and labourers, with a houseboat lashed alongside for passengers. This starts from Guayra on the second, third, and fourth Tuesday of each month. In the remaining week a self-contained steamer of the Matto Grosso Navigation Company makes regular trips between Jupia, 150 kilometres upstream from Epitacio, to Guayra and return. The journey to Epitacio takes about seventy hours, and to Jupia about thirty hours more. The return journey, with the aid of a 3-knot current, occupies about half that time, but all schedules on the Upper Parana are elastic and subject to cargo requirements.

The roar of the falls, but 2 miles away, and the mists rising from them, are ever present to all who live at Villa Guayra. The name "Sete Quedas," or Seven Falls, was given them by early discoverers on account of seven columns of mist, which are visible when approaching from higher ground. The rapids on the lake commence about 3 miles above the head-fall, which lies close to the Paraguayan shore. Beyond these, two islands cover a couple of miles in Guayra Lake before we reach Guayra Island proper, which extends for over 40 miles, dividing this section of the river into two main channels. Any attempt to cross the Guayra Lake below these islands is dangerous for power-launches, and fatal for rowboats or canoes, as yearly accidents prove. Indeed, although a slight bay protects craft moored to the water front, Villa Guayra, as the

Company itself now recognizes, would have been better located on a site on the same bank 5 miles upstream. An arrangement had been concluded with the Government for an extension of the railway to this "new port," and this line has actually been built. Owing to the change of Government in 1930, the contract, which included opening the railway to public traffic, has been temporarily suspended.

Guayra Cataracts and Gorge

A plan of the falls shows clearly the tendency, which is also evident at Iguazu, for the head-fall to work up the swiftest channel of the river, leaving



Sketch-map of Guayra Falls

side-falls to develop from surplus waters. As the head of the Guayra Fall is narrow in comparison to the width of the lake, the side-falls are proportionately numerous. Of these there are no less than seventeen, many of which are twin falls, owing to the intersection of rocky islands at the point of entry. The most comprehensive view of Guayra Falls is from the Paraguayan side, just as the fullest view of the Iguazu Falls is from the Brazilian shore. The best "close-ups" however, both at Guayra and Iguazu, are from the opposite banks. There can be no real comparison between the falls at Guayra and Iguazu. Guayra gives the impression of overwhelming power rather than beauty, and this is intensified by the stark basalt cliffs which bound the waters tearing through the

gorge. The gorge waters in the centre are piled and tossed many feet higher than the sides. The side-falls pour down their separate chasms with little softening accompaniment from vegetation, since periodic floods restrict the full growth of the surrounding forest to the tops of the cliffs. At the time we viewed this bewildering spectacle the gorge was about three-quarters full. That is, standing by the lowest side-fall, 4 kilometres from the head, we were about 40 feet above the main torrent. In low water this sinks another 80 feet, and the actual falls are by so much increased.

An accurate cross-section of the gorge has never been possible, but judging from its uniform character up to the point where the head-falls are now emerging into Guayra Lake, one may conclude that its bottom corresponds roughly to this latter width, *i.e.* from 50 metres to 60 metres across. While the general slope is fairly uniform down to the river below the gorge, there probably exist definite ledges marking the spasmodic progress of the falls as they worked upstream. Sr. Rafael Avente, a representative of the Matté Larangeira Company, who assisted to plan the site of Villa Guayra when it was yet forest, and in those days cut a "picada" down the gorge, described to me a phenomenon at a point 6 miles down, appropriately named "Corradera Brava," or "fierce rapid," which certainly indicates some serious underground irregularity of level, or massive obstruction to the current. The river here, as elsewhere in the gorge, flows at perhaps 20 miles an hour. The water becomes glassily smooth; there then appears at both sides of the cañon a crisp, upturning ripple, a kind of angry frill of water working towards the centre. This grows in intensity till both edges meet, when the whole water boils up into a tumultuous head, accompanied by a dull explosion, "like a charge of dynamite at the bottom of the river." The outburst is followed by a sucking-in of the water, till a giant whirlpool forms, its sides again reaching to both walls of the cañon, its centre perhaps 12 feet deep. This fills up, and the swift current again irons out the surface to an oily smoothness. The whole cycle takes about ten minutes, and is repeated without ceasing. We are left to imagine the potency of forces which can maintain such surface phenomena in the face of such a current.

I have spoken of viewing the Guayra Falls from the Paraguayan shore. Actually, there is some doubt as to the exact incidence of the frontier line between Paraguay and Brazil (Matto Grosso) upon the falls. The Commission entrusted with the boundary limit in 1872 appear to have had little knowledge of their real character. Thus, while the boundary line from the head-waters of the River Apa and thence along the water-parting upon the Amambahy and Maracaju hills is not questioned, the last few kilometres leading from the highlands to the gorge and falls have apparently never been definitely fixed. The terms of reference to the Boundary Commission apparently included a line from the Maracaju hills "to the falls of Guayra, or Sete Quedas." Paraguayans opine that this means a line running to the centre or "thalweg" of the rapids in Lake Guayra flowing to the head of the falls. Brazilians, on the other hand, maintain that the line should enter 4 kilometres lower, *i.e.* where the falls end and the gorge proper starts. Although the amount of territory concerned is insignificant, the point at issue, when finally settled, will determine whether Paraguay retains ownership of the whole of one side of the Guayra cataract

and gorge while Brazil holds the other, or lose her more spectacular portion. Since it has been proved that there can be no question of any major hydro-electric development at Guayra for many years to come, if ever, it will be a pity if the Governments of Brazil and Paraguay do not settle this difference of opinion at an early date, and so free the view-points adjacent to the falls from a political complication which tend to restrict the tourist traveller in his enjoyment of a unique spectacle.

One consideration which may affect Brazil's attitude to the Guayra boundary limit, is the fact that the gorge below the falls offers an ideal location for crossing with either a road or railway bridge. The total width is barely 300 feet, which could be covered by a single span, while both banks are of massive basalt and approximately level. Briefly, the Guayra Gorge presents conditions allowing a bridge to be built over the Alto Parana at one-tenth of the cost and with a higher factor of safety than at any other point on the whole river. The single bridge that spans it to-day at Jupia is over 1000 metres long, without approaches. An earlier structure suffered severe flood damage, leading to re-modelling of the original plan, before the present bridge could be built. Moreover, while the hinterlands of the state of Parana have such a long frontage to the river, there is no railroad or road leading from the Atlantic coast or from its capital, Curylika, to any point of its western frontier. Should such a line or road ever be constructed, Guayra appears to be its predestined terminal, since the low, flat-topped Maracaju tablelands offer an easy continuation across Guayra Gorge to the highlands either on the Matto Grosso or Paraguayan side.

It should be recorded here that the Matté Larangeira Company during the last five years has constructed four bridges connecting the islands between falls 18 and 15, which permitted views hitherto unattainable. Three of these suspension bridges were washed away by the 1929 flood, which rose above the outlook rock near side-fall No. 18. The last bridge of wood remained perched *in situ*, but is at present inaccessible.

Evidence of the successive formation and abandonment of side-falls by the Guayra cataract on its way upstream is given at Guayra Beach, a kind of rocky inlet about a mile below side-fall No. 18. The basalt cliff walls are the same height as those of the gorge, but its bottom has been choked with sand. At the time of our visit the floor was only gently awash with water entering from the river. Its total length is about 450 yards; near the centre is a large pool, which appears to have some underground communication with the river. This pool is never empty, and its water-level is liable to sudden oscillations up to 6 feet, without apparent reason. It forms a favourite swimming pool for picnic parties from Villa Guayra, but its habits are so well known that inexperienced bathers are always warned against suddenly finding themselves out of depth. Guayra Beach is strewn with large boulders, chiefly near the head and sides of the cañon, which are of the same basalt rock as the cliffs whence they have obviously been dislodged. It needs but little imagination to conceive the battering force of these rocks, losing nine-tenths of their inertia in a 20-knot torrent, and dashed against other obstructions, or rolled along the bottom of the gorge.

At the back of Guayra town, about 100 feet above zero-level at the lake, I

was shown a railway cutting, intended for the railway line but afterwards abandoned. Its sides disclose a terrace of pebbles, much waterworn and representing deposits on a former shore of Guayra Lake, or on the bed of some long-vanished stream. The terrace was about 4 feet thick, composed of weathered agate pebbles,* and was sandwiched unconformably, both above and below, with the familiar red soil of the forest which a few years ago covered this spot. The section exposed was about 40 yards long. While the pebble conglomerate itself proves but little, for the pebbles may have come to this resting-place from any distance, the terrace is interesting as evidence of either a much higher former level of Guayra Lake, or of a river which dried up as the waters sunk. So little geological field-work has been done in this part of Brazil or Paraguay that authorities are reticent in drawing conclusions. It is claimed however that the Serra Maracaju and Amambahy rocks belong to older igneous formations apparent on the Atlantic coast, while the bed of the Alto Parana, from Posadas to its extreme head-waters upon the Rio Grande, shows later basalts. These subsequent sheets appear to have been in general horizontal, accounting for the uniform levels at heights of 100 metres, 200 metres, 300 metres, and 600 metres from Misiones to Matto Grosso. If this were so, the Alto Parana river must have cut its way through these higher strata down to the present bed. Whatever the explanation, this upper basin of the Alto Parana, between its confining falls at Guayra and Urubupunga, is of great interest both from its extent and its intermediate position between the coastal and central plateaux of Brazil. It is to be hoped that, as the country opens up, further light may be thrown on the many interesting features associated with this great interior valley, apart from its role as a creator of magnificent waterfalls.

The forests bounding the Alto Parana from here onward must rank amongst the most magnificent in Brazil. They contain the usual percentage of excellent hardwoods which are worked at Guayra on a limited scale for local requirements, but here as elsewhere in Brazil's rainy tropic forests no attempt is made to utilize the softer timber which forms the bulk of these woods. Any forest excursions by the novice should be made when equipped with knee-boots or gaiters, gloves, and similar usual safeguards against insects, especially a minute pest known locally as "mariguy" or "bariguy." Orchids and other parasitic plants and creepers cling to the bark or droop from the forks of most trees. The deadly embrace of the wild fig takes its usual toll of forest weaklings, sending down long sucker roots to the earth, while its glossy foliage stifles its victims' struggles for sunlight. Any open space, by the side of a lumber track or round the fall of a great tree, is at once pre-empted by clumps of giant bamboo, which give a distinctive aspect to these riverside woods.

Forest paths have many an unexpected turn and cul-de-sac, and such excursions should not be undertaken without a guide. The native Paraguayan woodsman, who is the best worker on the forest as on the river, has a remarkable sense of direction.† A forest path or "picada" lightly "blazed" to some new

*I am much indebted to Mr. Campbell-Smith, of the Geological Section of the Natural History Museum at South Kensington, for his examination of the stones from this terrace, as well as for further references on the geology of this region.

†Mr. W. J. Harding King gives other instances of abnormal direction-finding, but in open desert country. See "Pioneer Desert Exploration," *G.J.*, vol. 77, p. 541, June 1931.

yerba groves may be several miles long and have a dozen different traverses; yet when the word is given to make for home he will unhesitatingly chop a short cut through dense undergrowth which will bring him straight to his starting-place. A similar instinctive sense is shown by pilots in charge of the river launches and barges, although not so much on the Parana itself, where open water and sky are always visible. Coming back from the Larangeira Company's yerba workings, there are long stretches on the upper reaches of the Amambahy and Ivinheima tributaries where the forest completely overshadows the water, so that on moonless nights these heavily laden barges appear to be steering through a pitch-black tunnel, broken by rocky ledges and sandbanks. Yet when his trick at the helm is over, one pilot will kick his sleeping companion with no further instructions than a brief "Here, it's your turn now," before he rolls himself into his blankets. The new man, taking over half asleep and without any apparent clue to position, twirls his wheel in the darkness with only rare mishaps. The explanation in both cases presumably consists in the sub-conscious memorizing of minute details of forest and river, imperceptible to others, which long practice has made automatic.

Even the wariest pilot however cannot foresee the snags, stones, or sandbanks deposited in the channel by recent freshets, and propeller damage on these launches is serious. Going over one of the Company's home-built craft, which for these upper waters are designed for 12 inches draft, I was surprised to see five propellers packed in readiness round the main shaft. The chief engineer told me that in a single season of low water one launch had broken fourteen propellers within five months! These are now purposely cast of aluminium in the Guayra workshops so that they break easily on any obstruction. A new propeller of this type can be refitted through a special manhole, with only half an hour's delay, but a broken tail-shaft means a broken trip.

Shortly after we arrived at Guayra, Mr. Raoul Mendes Goncalvez with two companions started on an inspection trip up-river, in one of these small launches, to Campanario, a journey of thirty-six hours. From this station he planned to go by motor car another day's travel to Campo Grande, on the São Paulo–Corumba railway line, and thence in two more stages of a day each to Rio de las Garzas (Egret River), one of the head-streams of the Araguaya river leading to the Amazon. His route lay mainly on the Matto Grosso divide, where the grass is short and the earth, except after heavy rain, hard and level. From Rio de las Garzas he intended returning in a single long day's motor run to Tres Lagoas railway station on the Alto Parana; a programme which was duly executed. This journey of 600 miles over the tableland prairies, or "chapadas" of Matto Grosso would have taken formerly, by mule or on horseback, over a month.

Our departure from Guayra took place a week later, the whole administration turning out for the usual farewell from the busy water front where a dozen steamers and launches and sixty barges are constantly coming and going. The captain of the port's powerful tug, supplementing the launch to which we were attached, took us in tow past the first islands, till the mists from Guayra cataract and the roofs of that oasis of efficiency, Villa Guayra, were alike lost to view. By nightfall we were steaming through the Matto Grosso channel of the river, with Guayra island slipping by.

The formation of islands on the Alto Parana in these reaches resembles

that of islands on the Uruguay river. Although their superstructure is of loose sand and clay they are anchored for the most part to a rocky base. In this they differ materially from islands on the Lower Parana between Corrientes and Rosario, Santa Fe, where the river bottom itself is sand and mud, and islands exposed to the current are forced downstream from season to season, or rather from flood to flood. Guayra island and lake appeared to their first explorers much as we see them to-day, but the channels and lands of the Parana Delta have altered out of recognition within living memory. Nevertheless the same process of wearing away an island's head while adding to its tail is evident in this upper basin, though in a much modified degree, with the result that most islands have a torpedo-shaped outline, the thick end pointing upstream. The vegetation upon them proceeds in three regular stages; first, river grass to consolidate the sand, then a sappy, white-leaved shrub, and, finally, the ubiquitous fig tree, which pits its tenacious and buttressed roots against the force of the current in a visible effort to hold the head of the island together. The way this tree grows new props to take a new strain whenever it is forced out of the perpendicular is an object lesson in self-taught constructional engineering. Periodic high floods, which determine the level of the islands, also prevent a more permanent type of forest tree.

Amid these surroundings we sidled upstream seeking slack water (the current is always swiftest under the highest bank), now on the Matto Grosso side, now on the Parana or São Paulo, but always through an untouched wilderness, its only visible habitations the rare cabin of a woodcutter. The forest on either hand is fiscal ground, and there is no charge for the cordwood supplied to steamers except the labour of cutting. It was one of these solitary woodcutters who rescued last year the survivor of two Italian aviators after their forced descent some 10 miles up the Paranapanema river, during an attempt to fly from the Atlantic coast to Matto Grosso.

The hills of Parana and then of São Paulo lift ever higher and closer to the river as Epitacio is approached. The heights of Matto Grosso, on the other hand, are only visible during the first day's travel; thereafter they retreat a full 50 miles westward. In consequence, the navigable reaches of side-streams entering this upper basin of the Alto Parana from the east are much shorter, and their current is swifter, than those entering from the west. Taking their volume and length as a whole, the eastern rivers are however much the more important. All these rivers offer tantalizing opportunities for exploration. If on the main stream one appears to be travelling through a natural preserve, what must be the profusion of bird and animal life in these tributaries, whose solitude not even a weekly steamer ever disturbs?

Even by the crew the journey from Guayra to Epitacio was not regarded as a humdrum affair. A keen watch was kept for any signs of Muscovy duck, the "pato real," largest as well as the best eating of their kind. These birds were so tame that they allowed the launch to splash to within 30 yards, while the captain blazed away with an ancient shot-gun; half a dozen made a welcome addition to the lean beef, which hung in the breeze from the awning. On one occasion a duck, falling in the water, was seized by a crocodile, so he was shot too, and both came on board together. Families of capivara* or water-pig

*The "Carpincho" of Argentina.

rooted along the banks; no tapirs appeared, these keep in the riverside thickets, and only when pursued take to the open river. The pilot's accustomed eye pointed out other hunters in the light and shade of the forest; kingfishers and cormorants watching for a chance to dive; some kind of "onca," or forest cat, stretched along an overhanging bough; once even a python, silently swimming with outstretched head. In the river shallows, pink flamingos and herons eyed us motionless; a couple of brightly coloured macaws crossed our bows, and oftentimes a flight of snow-white egrets streamlined against the wind. The carrion crows seemed to have stayed behind at Guayra, but somewhere in the blue a hawk always hovered, and before nightfall flocks of little green parrots flew chattering, two by two, across the river into the Matto Grosso sunset. A forest deer, about 30 inches high, was sighted swimming across the river in a broad reach a mile wide, and captured by hand from the canoe after a gleeful chase, during which it doubled like a hare. Stowed in the hold for dinner on the return trip, it escaped, much to our relief, before arriving at Epitacio.

The Alto Parana is a fisherman's paradise. The "dorado," or golden South American salmon, is a misnomer, for the so-called "salmon" more resembles the true salmon in appearance, although not in flavour or habit. But the dorado's gameness, as well as his excellent eating quality, makes him the chief river fish. It is distributed over the entire Parana system and the River Plate. This fish bites best after a period of low water, when the river is rising. I fished the Guayra gorge in May in half flood unsuccessfully, but was told that in September and October they could be caught in any accessible pools actually under the falls. The guide added that they waited here to catch the small fish carried over the falls, and that the biggest fish lay highest up the current. The problem here, as elsewhere, turns on knowledge of local habits and feeding grounds of the fish, for above Guayra the dorado appears to be freely caught in any season or state of the river.* The "boga," common also in River Plate waters, has a small pursed mouth, and sucks in its food, even taking dough or fruit as bait. The appetite of the catfish is catholic, and some varieties grow to great size. At Guayra Port, where much food and refuse is thrown out near the bank, I was shown a photograph of a catfish recently caught weighing 176 lbs. As the line was too weak to land the catch alive, it was first killed by a couple of revolver shots in the river—a very sporting affair. One of the chief sources of fish food must always be the swarms of insects, ants, beetles, butterflies, dragonflies, and other small fry, which eventually find their way into the water. I have seen rocks covered with thousands of small yellow butterflies, slaking their thirst in the river.

Every afternoon the captain abruptly announced "In half an hour we shall be fishing," and we would duly barge into the bank, always on the Matto Grosso shore, and alongside the outlet of some stream. Any of the numerous mouths of the Ivinheima seem to be specially good fishing grounds. Instantly a dozen lines, baited with raw meat on hooks 1 inch to 3 inches long, were in the water. Smaller meat bait is liable to be snatched by the voracious, parrot-jawed "piranha," a dangerous nuisance. The upland forest provides a thin

*There is a Dorado Club in Buenos Aires, to which those interested in the sport should apply. See also 'The Golden River,' by Major J. W. Hills and Ianthe Dunbar.

bamboo which will hold a big fighting fish as well as any split-cane rod, and this, with 30 feet of twisted piano wire, was regarded as a refinement of the fishing art; for the others 100 yards of stout tarred twine sufficed to twirl the heavy bait out and slowly pull it in. Within twenty minutes we averaged seven or eight fish, from 15 lb. to 30 lb. each; the rope was cast off, and the journey resumed.

The height reached by the 1929 flood at Port Epitacio is marked by a black band on the side of a galvanized shed on the São Paulo bank. Our pilot stated that the river at our arrival stood some 6 feet above zero, making the total flood about 30 feet above zero, a somewhat surprising figure, given the width of the river which measures 1000 yards within its normal banks, but much more when they are topped. On the farther shore were corrals for cattle brought in for shipment from Matto Grosso to the big "frigorifico" outside São Paulo city. Our last glimpse of the Alto Parana was that of two fishermen landing on the roots of a giant fig tree, and taking from their canoe half a dozen big fish, caught within the hour.

Epitacio settlement consists of a single row of twenty frame buildings, three of which are barbers' shops, and stands half a mile back from the river with the passenger station, although the rails are continued to the waterside. The whole place reeks with malaria. Yet, hemmed in by giant forest in its newly burnt clearing, three-year-old Epitacio does a brisk trade with a nearby Hungarian colony of about 6000 folk. Passenger trains make the daily run of 897 kilometres (557 miles) to São Paulo; the price of a first-class ticket, including Pullman sleeping berth, was 61 milreis, about 17*s*., at current exchange. This charge, which is obviously uneconomic for a distance considerably greater than from London to Aberdeen, is evidence of Brazil's policy of expansion towards her western frontier, after her population has for three centuries been confined on or near the Atlantic coast.

The Hungarian farms are comparatively small, only 30 to 50 acres, the first two years being occupied in clearing the heavy forest, logging and shipping the profitable timber, including large quantities of rosewood. Their neat cottages, of a type utterly unlike the accustomed tile-bedecked Brazilian dwelling, stood in kitchen gardens, flanked by the inevitable mandioca and pineapple patch. Mandarin oranges were offered in baskets at the stations, nearly as large as the ordinary orange sold in London streets, of delicious flavour and with a minimum of pips. Fascinated, I watched a fellow passenger consuming a dozen single-handed within the hour, causing me to revise all my previous estimates on the world's saturation point for citrus fruit.

Anastacio town, 59 miles from the Alto Parana, is barely twelve years old. It already has ten thousand inhabitants, all of whom, including planters for 30 miles' distance, are engaged in growing, merchandizing, or transporting coffee. It is in fact a typical "boom" western coffee town. Arriving in São Paulo after twenty-six hours' train journey (scheduled at twenty-two hours) I found at the hotel an international Coffee Congress in being, represented by delegates from Brazil (São Paulo, Parana, Rio, and Minas Geraes States), Colombia (the delegate arriving by aeroplane down the Pacific Coast), Holland (for the Dutch East Indies), and England (for Mysore and Kenya). The object of the gathering was to agree on the best method, by destruction

or otherwise, of reducing the world's existing coffee stocks, some of which we had just witnessed being so well and successfully harvested.

Two or three motor trips to Santos, down the hair-raising mountain road of the Serra do Mar, with its 8 kilometres on a 12 per cent. grade, and we boarded the home-going steamer.

As it passed out of the Santos channel into the open sea, the mists on the heights were already blackening into cloud. Up there the raindrops were falling into the great Pedras reservoir, whence they would in time begin their 2000-mile journey; passing into the Tiete and so downstream to the Alto Parana; boiling through the Guayra cataracts, and through the crazy waters of its gorge; whirling past the smoke that rises above the forest from the Iguazu Falls; leaving the last rapids of the river at Apipe to join the slow-rolling Paraguay, and so through the winding Delta channels and the flats of Buenos Aires, joining with the muddy River Plate and, at long last, the blue Atlantic Ocean.

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: Not very long ago a much-travelled man, not an explorer but one who had travelled a great deal over many parts of the Earth—it was the late President of the Manchester Geographical Society—told me that in all his travels nothing had impressed him more than that great river the Parana, with its great tributaries the Paraguay and the Pilcomayo, and many other smaller ones. It forms in its basin a matter of geographical and other interests, and it is somewhat curious that it should be still comparatively little known. We are all the more glad therefore to have a lecture this evening from one who can give us an account of it at first hand. Mr. Barclay has been a Fellow of this Society for many years. As long ago as 1913 he received the Back Grant for his geographical work in South America. He has read papers to the Society and has given us some admirable articles. He was one of the secretaries to Sir Maurice de Bunsen's mission to South America in 1918, and has been general secretary to the Buenos Aires British Trade Exhibition which was held in the spring of this year.

Mr. Barclay then read the paper printed above, and a discussion followed.

The PRESIDENT: We are fortunate in having with us to-night Sir Maurice de Bunsen who, as I said before, went to South America on a mission in 1918. I will ask him to be so kind as to say a word or two.

Sir MAURICE DE BUNSEN: It is a very great pleasure to me to spend an evening hearing about these great waterways and seeing the pictures of them that have been shown to us. I have had the advantage of seeing them with my own eyes in the company of our lecturer when I had the honour to represent this country on the mission to the different states of South America in the last year of the War. England had been cut off from relations, or very close relations, with South America all through the War and our place had been taken by others. As the War drew to its conclusion it was thought advantageous that a mission should go to see our friends in the Argentine Republic and in Brazil and the other countries of South America. Our hope and intention was, very shortly, at the end of the War to resume with those countries the close relations which it was our pride and advantage to have kept up with them for so many years. So off we went in the last year of the War, a mission of eight members, one of whom was Mr. Barclay. There were a Member of Parliament, an Admiral who had fought his ship at the Battle of Jutland, a General, and one or two experts from the Foreign Office, and

we had a very pleasant and interesting time. We tramped about the country in South America, I may say without any hardship, for wherever we went we were greeted by hospitable Governments as their guests. During our stay we were lodged in magnificent buildings, we were taken about the country in special trains and steamers, and had every advantage we could possibly have. We saw only very little of the places we have heard about this evening. We were in Buenos Aires hardly a week and in lesser places only perhaps a day or so. But even that was enough to give us an impression of the vastness of South America. I do not know how many thousands of miles we must have travelled, but we were hard at it for more than four months. During May, June, July, August, and September we were travelling all the time except when staying occasionally in different capitals. After visiting Buenos Aires we went up by land to Paraguay through the Argentine side by Entre Rios and Corrientes. In doing so we had to cross the Parana river twice, first of all not very far from Buenos Aires. The whole train was taken on to the ferry boat and we had about three hours' sailing to get to the other side of the river where the landing is. Then we had another day or two's travelling and we crossed the Upper Parana where it forms the boundary between the Argentine Republic and Paraguay. One of the members of our mission was Mr. Follett Holt, who had to do with the South American railways. He had hopes that through Entre Rios and Corrientes the line might be extended to northern Paraguay and perhaps form the nucleus of a vast railway line which would extend some day or other all the way to Panama. However it has not come to pass yet, and I do not know whether it ever will. But that shows you how ambitious the views of the South American railway people are.

When we got to Paraguay I recollect having a conversation at Asuncion, where we were very hospitably entertained, with some of the members of the Paraguayan Government. They were talking a great deal about the Chaco country of which we heard something this evening and which is still a subject of dispute between Paraguay and Bolivia. I hope that, through the instrumentality of the League of Nations, war over that subject will be prevented and that a settlement will one day be arrived at.

Then we went on one of the typical river steamers that ply on the upper waters of the Parana and belong to the great Mihanovich line. We were fortunate in having with us Don José Dodero, one of the principal directors of the line, who is present this evening and knows more about that river than anybody else. I had a very interesting journey down the river to Rosario, where we left the steamer: I think it took us two days. Rosario is a most interesting place: a great city with three or four miles of river frontage on which the huge grain elevators are situated, and all the grain, or a great part of it, comes there from Argentina. At Rosario we left the great Parana, and a few days afterwards went off westward into Chile and so onward on our mission.

I am not going to say anything more about it except that it has been of much interest to hear from Mr. Barclay his impressions of the journey up the river and to see illustrations of the scenery and the wonderful falls of Iguazu and Guayra which extend along a very wide expanse of country. It was a great disappointment to me on that mission that, having got as far on the Parana as the point where we crossed over into Paraguay, we did not then break off, for I do not think it would have been more than a couple of days to go to the great Iguazu Falls. But some members of the mission were very anxious to get home again and we cut our journey short. I have never ceased to regret it. I have greatly enjoyed listening this evening to a most instructive lecture from one who knows his subject thoroughly. There are very few who have the same competence in South American geography as Mr. Barclay has. Two years ago he produced a map which

I dare say some of you know. I refer to it very often. The only drawback about it is that it is so large and covers so great an area that you have to spread it out on the floor when you wish to consult it and it takes some time to roll it up again. But when you study it you find it of great interest.

The PRESIDENT: As he is here present I will ask Don José Dodero to speak to us this evening. We have been assured by both the previous speakers that he knows the Parana as well as anybody.

Don JOSÉ A. DODERO: I was rather surprised when the President told me to-night that he would expect me to say a few words. I do not think I can say very much more of our river Parana than Mr. Barclay and Sir Maurice de Bunsen have just said. I do not think for a moment there is any man who knows anything more about the Parana than Mr. Barclay. As a matter of fact, I have been the whole time listening to him because I have been learning myself. I know that country fairly well. I was there for the first time in 1909; but I think Mr. Barclay was there before.

There is nothing else for me to say but to thank the President and the Royal Geographical Society. I was very interested to find how you British people try to educate your population about the big interests you have abroad. I think that by giving this sort of lecture, little by little in a very agreeable way, you come to know all about the world. I hope I shall have the privilege of being able to attend more meetings of the kind. I want to thank you specially for the invitation to attend this evening and to congratulate Mr. Barclay on what he has said to-night.

The PRESIDENT: I do not know that we have ever listened to a lecture in this hall which has been so full of contrasts. I am fortunate in having been able to make a note or two, for I am quite certain that in the beauties of the falls and the interest of the latter part of the lecture I might have forgotten, though for a moment only, the first part. I suppose we all have something that we think of often, and, among other things, I wonder where all the surplus population of many countries will go to in the future, and whether this part of the world is going to be one of the places which will receive the thousands and hundreds of thousands increase in our populations which we may expect in the future. If the area just outside Buenos Aires was more or less a desert some years ago and is now a thriving place, why should not places farther inland be turned to the same use?

You have, Mr. Barclay, given us an evening of entrancing interest, and told us about things that we knew, certainly I myself and I believe others, very little about. I would ask you to accept the best thanks of myself, of this audience, and of the Society for your interesting lecture and the graphic description of those beautiful waterfalls about which you have told us. May I say to Don José that we shall be very glad to see him here whenever he likes to come.

Corrigenda.—*Page* 87, 16 *lines from top:* for "volcanic" read "igneous"
Page 87, 20 *lines from top:* after "much-eroded" add "Trias."
Page 92, 19 *lines from bottom:* for "10*s*." read "15*s*."
Page 92, 5 *lines from bottom:* for "15,000" read "1500."
Page 93, *last paragraph:* second sentence should read "*Silkworms* in the Upper Parana country yield eight to fourteen crops of *cocoons* a year, compared with *one* and three crops in Italy and Japan."

TIDAL OBSERVATION ON THE GREAT BARRIER REEF EXPEDITION

With a note on Harmonic Analysis

MICHAEL SPENDER

The Automatic Tide-Gauge

THE survey of Low Isles (Lat. 16° 23′ S., Long. 145° 34′ E.), the headquarters of the Great Barrier Reef Expedition of 1928–9, was described in *G.J.*, vol. 76, p. 193 (1930). It was related to Mean Sea Level by the use of a recording tide-gauge developed by Dr. Rude of the U.S. Coast and Geodetic Survey, and described as Portable. The instrument, which is the property of the Society, was made by the Bausch and Lomb Optical Co., and cost $208. Plate 3 is a photograph that was taken during the actual working of the instrument and includes nearly everything comprised in the term Portable Tide-gauge. This mechanism, with its lid, the float, attachments for each end of the float-tube, and accommodation for the record charts, is delivered in a substantial wooden chest measuring 26×18×14 inches, and weighing 90 lb. when full. It is transportable equipment compared with a permanent shore installation, but not only is its portability restricted, but it does not include the whole of the equipment of a tide-gauge. The instrument is described in U.S. Coast and Geodetic Survey, Special Publication No. 113. The float is a hollow cylinder of brass, 15 inches long and of such a diameter that it floats freely in the tube of 3½ inches internal diameter; it is counterweighted with lead shot until it just fails to sink in kerosene. A phosphor-bronze wire (30 S.W.G.) leads from the float over a pulley at the top of the float-tube on to the drum. This drum is the essential characteristic of the gauge. A screw-thread has been turned into its circumference so that the wire falls into an endless groove as the float rises: to each foot lift of the float the drum makes a single revolution; the tension is maintained on the wire by a watch-spring coiled inside the drum, and any trouble with counterbalance weights is eliminated. This device, without any attention but inspection and a few drops of oil, gave no trouble over the whole period. The motion of the drum is conveyed to the pencil through a gear-train of interchangeable members, and the single break in the record was due to the inadequate locking of these gear sprockets. They were always a source of anxiety because they were not keyed to their respective shafts and depended on the pressure of a terminal nut to lock them. The nuts are cut with a fairly high-pitch thread, and although in the absence of spring washers various make-shifts were tried, the nuts tended to work loose with the vibration of the gauge to every sea that passed it. The drum shaft is of steel, which rusted badly in spite of a layer of vaseline; it would seem that phosphor bronze could have been employed for this shaft. The pencil shaft with its deep helical slot is of phosphor bronze and suspended in ball-bearings.

The clock-cylinder is detachable. The bow-arc that fastens the overlap of the recording chart is made with the idea that the tracking pencil should ride over it, so allowing a week's record to be taken, in which the time drum makes

a revolution every forty-eight mean solar hours (see Fig. 1). As things turned out, a special shoe had to be made of sheet silver in order to help the pencil over the bar. The track is faint but legible; we have had no experience with a stylus recording pen.

The record sheets are of stout ruled paper, 20×7¼ inches. Each arrangement of gears corresponds with a different chart: there are in all five combinations, allowing tides varying in range from below 6 up to 25 feet; thus with pulley gear 72 and screw gear 72, a maximum tide of 17 feet can be recorded on a scale of 1:30. Heights are accurate to a tenth of a foot and the readings were checked against the standard pole as often as possible. Standard time was kept: it was obtained from a theodolite observation on the sun once a month to check the rate of a chronometer watch. The changing of the chart, which was done once a week when possible, was not always easy during a high wind: once I had to fish my record from the sea some distance to leeward. An expedition working away from a base for any length of time would

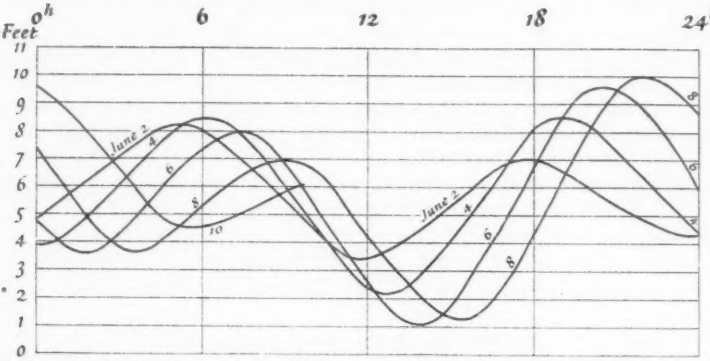
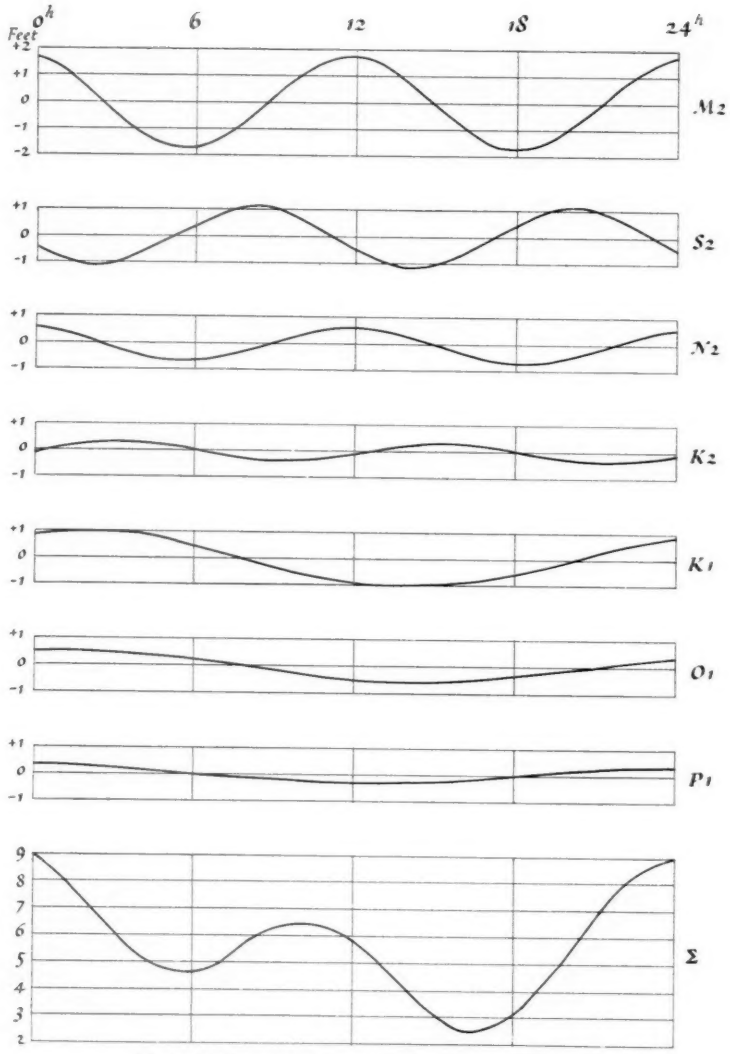


Fig. 1. Reduced trace of the Tide-gauge Record for alternate days in the period June 2–10: the drum turns once in forty-eight hours, and the intervening days are on the other half of the sheet

probably feel surer with an extra time-drum in their equipment, so that the record could be changed under shelter and they would be insured against trouble with the clockwork. A cylinder can be so easily rolled over the edge of a staging into the sea.

The float tube has to be of 3½-inch standard galvanized iron piping. This would not readily be obtainable in countries where metrical measurements are employed. Fortunately in Australia the American thread is used for the coupling sockets; the English standard is different. The piping weighs 8½ lb. and costs four shillings each foot run: it must be cut to length, threaded at the base for the throttle orifice, and at the top for the connecting socket. At Low Isles preliminary measurements indicated a possible extreme tidal range of 11½ feet (actually 1 foot in excess of the maximum range recorded). After allowing 30 inches to clear the waves at the top and 1 foot excess at the base, we were obliged to order a 15-foot length of piping; such a length is heavy and awkward to handle, especially at sea in small boats. In the instruc-

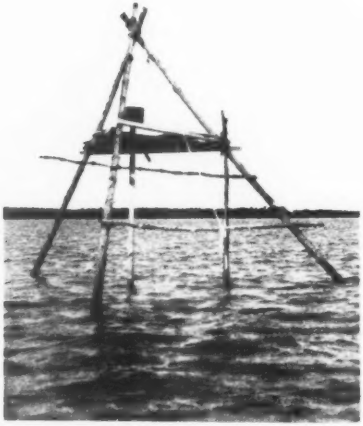


M_2 *is the Principal Lunar Semi-diurnal Component*
S_2 *Principal Solar Semi-diurnal*
N_2 *Lunar Elliptic*
K_2 *Lunar Semi-diurnal Declinational*
K_1 *Luni-solar Diurnal Declinational*
O_1 *Lunar Diurnal Declinational*
P_1 *Principal Solar Diurnal Declinational*
Σ *is the sum of these components, the predicted tide*

Fig. 2

Phot. J. S. Colman

1. Collapse during erection of tripod: large derrick being brought into position



2. Staging, gauge, and tick-pole seen at half-tide

3. Tide-Gauge in position and operating

tion booklets the makers recommend that the float tube should be fastened to a conveniently available jetty, the float attached to the wire and lowered down the tube, and the clockwork finally slipped on the top, where it may be readily inspected by walking down the jetty. This particular survey party was working where no such facilities were provided. Only by swimming amongst coral in the darkness (a procedure damaging to the person) could a site be found that did not dry at the lowest tides, which was reasonably sheltered from the worst weather and would not give spurious results through the water being held up in a pool or on the reef. A staging had to be erected strong enough to withstand the weather and support the tube, having as part of its structure a platform accessible at most states of the tide on which one could work when changing the record sheets.

A tripod of members 30 feet long was eventually constructed. Mangrove was the most suitable timber, and trees (Rhizophora) tall and straight enough were to be found in the swamp at Low Isles, but there was no way of getting the trunks out once felled. The *Luana* was therefore sent to the Daintree River, 7 miles away on the mainland, where she secured four fine poles. They were very heavy, of the order of 5 cwt. apiece, but since they sank in sea-water it was possible to lay them in position on the sea-floor by co-opting the entire expedition at 2 a.m. one morning. During the day the water at the position was rarely less than 8 feet deep. We were not equipped to carry out work on this scale, and the course of the work at first was only a series of disasters at the end of which everything lay in a hopeless tangle on the sea-floor. That the staging was eventually erected was largely due to the exertions of Mr. Carter, a light-keeper, and his genius for making the best use of the ropes and tackles supplied to the lighthouse for maintenance purposes.

The general plan, much confused when the anchors dragged and the poles moved out of position, was that a small derrick should serve to hoist a large derrick (the fourth long pole) which in its turn should hoist the whole tripod. In this way the structure was eventually erected. Plate 1 was taken during the operation and indicates the scale of the work. It stood up to some severe northerly weather exceedingly well, nor did it collapse when at a later date the whaleboat broke from its moorings and bore down upon it. The position of the gauge is shown on the map following p. 272, *G.J.*, vol. 76, September 1930. A record, continuous save for a break from 0900 4/5/29 to 0925 5/5/29, was obtained from 1000 8/2/29 to 0130 24/7/29. The records are referred to a datum plane below chart datum level, so as to avoid any risk of negative readings. The chart datum adopted was that established by H.M. Survey Ship *Penguin* in 1905 and was 17 feet 2 inches below the lighthouse step: gauge datum was 18·33 feet below the same step, and is hence 1·16 feet below chart datum. A ranging rod painted in tenths of a foot used as the standard pole may be seen in Plate 2, which shows the structure complete and working. The level of these graduations was checked against the lighthouse step three or four times during the run of the gauge.

The Tides as they appeared

The tides we experienced at Low Isles struck most of us as capricious and unreasonable. Dr. Doodson's reassuring observation on their normality,

quoted in my paper (*G.J.*, 76, 195), surprised many of those members of the expedition who, accustomed to the tradition of the apparently straightforward tides about the English coasts, found the tides on the reef consistently baffling.

The diurnal inequality causes consecutive tides to vary considerably in height, a fact that Captain Cook was unacquainted with before the *Endeavour* went ashore on a coral reef in 15° 47′ S., 35 miles north of our base. It was at the time of the full moon spring tides of June 1770; the ship grounded "at about the Top of High Water," a few minutes before 11 p.m. on June 11 (cf. Fig. 1). The succeeding high water at 11 a.m. was probably at least 2 feet lower: "we try'd to heave her off without Success, she not being afloat by a foot or more, notwithstanding we had thrown overboard 40 or 50 Tuns weight" consisting of "Guns, Iron & Stone Ballast, Casks, Hoop Staves, Oil Jars, decay'd Stores, etc." Their situation was very serious: it was after full moon, and among her seamen many must have known that the tides were almost certainly "taking off" and that there was a risk of being "neaped" on the reef; further, when the evening tide began to rise, the ship made great quantities of water. "At 9 p.m. the ship righted, and the leak gained upon the Pumps considerably. This was an alarming and I may say, terrible, circumstance, and threatened immediate destruction to us. However I resolved to risque all and heave her off in case it was considered practical . . . about 20 Minutes past 10 o'clock the ship floated" ('Captain Cook's Journal.' Edited by Admiral Wharton. London 1893, pp. 274 *seq.*).

This was an unfortunate introduction to the phenomena of diurnal inequality. Nevertheless Captain Cook was the first mathematician to observe this normal sequence of the tides within the tropics; he notes it at the end of his summary account of New Wales in a characteristically attractive paragraph (*loc. cit.*, p. 317): "Another thing I have observed upon the Tides which ought to be remarked, which is that there is only one high Tide in 24 Hours, and that is the night Tide. On the Spring Tides the perpendicular rise of the night and day Tides is not less than 3 feet, which is a great deal where the Tides are so inconsiderable, as they are here. This inequality of the Tide I did not observe till we run ashore." The use of the phrase "high Tide" distinct from "high water," should be noted. In Fig. 1 the record of the tides of 2–10 June 1929 (new moon springs) is reproduced. The series is likely to be very similar to the tides of June 1770.

The Harmonic Approach

In the 'Mécanique Céleste' (iv, §§ 16 *seq.* (1798)) Laplace considers the state of affairs at the Earth's surface in so far as it is influenced by the moon and the sun. The system is naturally not static: in order to deduce the complex total force in this dynamic system, he sums a number of simple terms or *partial forces:* in fact, he expands the tide-generating potential into a number of simple harmonic terms, of periods indicated by the motion of the moon, sun, and Earth. Laplace also extended the idea to consider the tide as experienced at any point (in the sense of the height of the sea above low water at that point), to be the aggregate of a number of *partial tides* (flux partiels) which could be referred to corresponding terms in the expansion of the potential.

By the time Kelvin turned his interest to tides, the thing had become a

practical problem, particularly for the Indian ports and for Aden. The British Association appointed a committee, and records began to be taken on automatic gauges. The usefulness to Kelvin of the method developed by Laplace was that there was no need to consider the dynamic connection between the tide-generating potential and the actual tidal movement experienced. "The *height of the water*," he wrote, "at any place may be expressed as the sum of a certain number of simple harmonic functions of time, of which the periods are known, being the periods of certain components of the sun's and moon's motions" (Thomson, *Brit. Ass. Rep.*, xl, pp. 120–151 (1870)).

Laplace, in his analysis, spoke of the various simple terms as though they were potentials set up by a number of "astres fictifs." The idea is one of convenience. It is required of an "astre fictif" that it should move at constant speed at a constant distance from the Earth in the plane of the Earth's equator; the necessity of postulating a multiplicity of such satellites arises because neither sun nor moon fulfil these conditions. Kelvin laconically remarks (Thomson, *Brit. Ass. Rep.*, xxxviii, pp. 489–510 (1868)): "One of the fictitious stars is what is called commonly in England the 'mean sun.'"

Thus one of the most important component terms of the tide is called M_2: it has a period of 12·4206 hours and may be considered as the tide that the moon would produce if it moved in a circular orbit in the plane of the Earth's equator.

The moon differs from this ideal satellite in that it moves at varying distances from the Earth in a plane which does not include the equator. We may take these defections one after the other. In the first case the effect is as if the amplitude of the M_2 term (otherwise known as the principal lunar semi-diurnal) varied at a rate which is slow compared with its period. The amplitude of the total tide (which proceeds continually with two high waters in the day) reaches a maximum when the moon is close at perigee, and falls to a minimum again at apogee: the interval between successive passages through perigee is the anomalistic month of about 28 days. This slow variation of the amplitude can be taken at once as the sum of the main term M_2 with another subsidiary term of slightly differing time-period. The heterodyne in wireless telegraphy and beat notes in acoustics are the more familiar examples of the effect of the superimposition of nearly like frequencies. At present we are only concerned with the time-period of the subsidiary term: the conditions are satisfied with a term having a period of 12·6584 hours, which will come into phase, thus reinforcing the main term to maximum amplitude, once every anomalistic month. This term is N_2 (larger lunar elliptic) and modulates the total effective tide as required by the astronomical theory.

The disturbance due to the declination of the moon's orbit is slightly more involved. The first effect of the moon being out of the equator is a diurnal tide, that is, one having only a single high water in the day of twenty-four hours. This tide has a daily range that passes from zero through a maximum to zero again as the moon crosses the Earth's equator, reaches maximum declination and returns again. The interval between two tides of zero amplitude is the time taken for the moon to make half a revolution about the Earth relative to the fixed stars, *i.e.* half a tropic month. The tidal phenomenon may be considered as due to the sum of two terms, K_1 and O_1, of slightly differing periods and equal amplitudes. The periods are actually 23·9345 and 25·8193 hours

respectively: the suffix 1 to the term signifies that the component is diurnal. Since declination slightly reduces the originally postulated semi-diurnal tides, an additional semi-diurnal component K_2 has to be introduced to modulate them so that their magnitude changes with changing declination.

In exactly the same way, the sun causes a component S_2 (the principal solar semi-diurnal) corresponding with M_2: the term analogous with N_2 due to the ellipticity of the orbit is small and may be neglected. The two interfering diurnal components caused by declination are P_1 (principal solar diurnal declinational), and another component of the same speed as, and therefore contained within on analysis, the moon's K_1 (which is therefore described as the luni-solar diurnal declinational).

The generalized conclusion (cf. Doodson, *Roy. Soc. Proc.*, Ser. A, 106, p. 513 (1924)) is then, that the tidal oscillation may be found on analysis to be equivalent to the sum of a number of harmonic terms with speeds derived in the manner indicated from the theory of the disturbing forces. Each term will be of the form $H \cos(nt-\kappa)$ where

H = the amplitude of the constituent in feet,

n = the speed in degrees per hour, *i.e.* $360°/T$, where T is the period of the component,

t = the time in hours after an arbitrary zero, *e.g.* midnight of Standard Time,

κ = the phase lag of the term, different for different terms and a function of longitude, the arbitrary time zero, etc.

The Tides as they are

The tides of our English coasts have only small diurnal components. The sequence of neaps and springs is however most easily understood as the consequence of M_2 and S_2 passing in and out of phase. But it was the perplexities of the tides in the tropic seas that led to the practical development of tidal theory: and so rapidly did the theory "rationalise" these difficulties that Kelvin, as early as 1870, was able to write of the tides in the Indian Ocean:

"The tides in those seas are commonly designated as 'irregular.' That designation results from a confusion of terms, 'irregular' being used as if synonymous with complicated. The truth is that the tides on the European coasts of the Atlantic are irregularly simple: those in all other seas are comparatively complicated, but regular and explicable."

Such anomalies as remain are due either to unpredictable meteorological effects or to distortion of the tidal wave caused by traversing a relatively shallow sea. The first of these can naturally not be brought into the scheme; but the effects of shallow water can be regarded as equivalent to the addition of an overtide of speeds 2, 3, 4, etc., times the original wave. The classic example is the double tide in the Channel between Portland and St. Catherine's caused by M_4, the first overtide of M_2. This is the only overtide usually evaluated for approximate prediction, unless an extreme case such as the Thames estuary is being considered. A further term MS_4 is demanded by theory in shallow water on account of the interference between the two principal terms, M_2 and S_2; its speed is the sum of the speeds of these two terms.

The Low Isles tides, typical of the tropics, show the influence of the diurnal

components: these, when they are in phase with one another, have together an amplitude as large as M_2. Under certain phase conditions therefore one of the semi-diurnal tides will be considerably reinforced and the other sensibly masked. This concurrence of events takes place in winter and summer, *i.e.* at the solstices. This is the phenomena of one high tide in the day, described by Cook: the tide of 10 June 1929—in Fig. 2—is characteristic. In the winter (June) the low tide is by day: work is therefore greatly hindered in December on the reefs, because the only low tide is in the middle night watch. Some of our midnight excursions on to the reef flat with lanterns were nevertheless quite amusing; there is something comic about a fish leaning against a rock fast asleep.

The Analysis of the Observations

In Fig. 2 (on plate) the components of a single day's tide have been laid out and their sum plotted as the predicted total tide. In order to compute these terms it was necessary to know the amplitude, time-period, and phase lag of each component, and the position of Mean Sea Level. We have already shown that the period, and hence the n of each component, is indicated by theory. The amplitude H and the phase constant κ must be worked out from the record.

A record of hourly heights for a minimum period of one lunation (twenty-nine days) is required. "In the analysis it is necessary that these hourly heights be combined in such a way as to magnify one constituent relatively to all others, and in practice only linear combinations are used" (Proudman, *Encycl. Brit.*, 14th ed. 22, p. 203 (1929)). For instance, at intervals of twelve hours the component S_2 will always have the same value: any other constituent will occur in a different phase at the end of this interval, and could be considered as an error in the reading of S_2. If readings be taken over a sufficient period of days, the average value deduced for S_2 would be sensibly correct. This is only the crudest possible statement of a procedure which is now highly refined and complex. It is easy to see that modification of this simple method will be required for most of the constituents, for only in the case of the S terms can an interval of an integral number of mean solar hours be chosen: in the analysis of the smaller terms the results of the preliminary analysis of the large terms can be used (cf. Admiralty Publication, 'Instructions for Analysing Tidal Observations.' This is the method devised by Dr. Doodson, and by its use much of the labour required by earlier methods is avoided).

The Tidal Institute at Liverpool interpreted our results into the following form:

	Value of H in feet									
Central Day 1929	A_0	M_2	S_2	N_2	K_2	K_1	O_1	P_1	M_4	MS_4
February 21 . .	5·98	1·75	1·05	0·53	0·28	0·75	0·49	0·25	0·01	0·02
March 15 . . .	6·16	1·75	1·05	0·58	0·28	1·02	0·48	0·34	0·02	0·01
April 13 . . .	6·22	1·65	1·05	0·68	0·28	1·01	0·46	0·33	0·01	0·01
May 12 . . .	5·99	1·65	0·94	0·76	0·25	0·97	0·39	0·32	0·04	0·02
June 10 . . .	5·69	1·68	1·10	0·56	0·30	0·91	0·47	0·30	0·02	0·01
July 9	5·61	1·75	1·12	0·57	0·30	0·95	0·46	0·31	0·01	0·01
Mean Value . .	5·94	1·70	1·05	0·61	0·28	0·93	0·46	0·31	0·02	0·01

with a similar table under the same arguments, having the following mean:

	Value of g in degrees								
	M_2	S_2	N_2	K_2	K_1	O_1	P_1	M_4	MS_4
Mean Value . .	278·4	246·8	257·3	246·8	190·6	154·4	190·6	125·0	40·0

A_0 gives the height of Mean Sea Level above the zero of the Tide-pole. The immediate purpose of the tidal observations was to discover Mean Sea Level (cf. 'Barrier Reef Exped. Reps.' (Brit. Mus.), vol. iii, no. 2 (1931), pp. 22, 99), and relate it to some fixed object on shore—in this case the stone step at the entrance to the lighthouse.

g is the phase lag κ adjusted for the longitude difference between Low Isles and Greenwich to give prediction in Standard Time.

Tidal Prediction

The practical value of the harmonic constants is in tidal prediction. Full instructions are given in the Admiralty Tide Tables, Part II, and it is not proposed to deal with the matter here. The important thing is that by means of a very simple arithmetical procedure in which each term is evaluated for every hour of the day (again, devised by the Liverpool Observatory and Tidal Institute), any seaman has a means of predicting the tide with a high order of approximation. Where the tide is of a so-called "mixed" type, where in fact the diurnal components are of any appreciable magnitude, the only other available methods of tidal prediction may provide results "so wildly inaccurate that the time found may be more nearly that of low water than of high water" (Commander Warburg, R.N., 'Tides and Tidal Streams,' Cambridge (1922)). "MARINERS ARE THEREFORE ADVISED TO USE COMPUTED HEIGHTS" and "Harmonic constants should be used in preference to either Non-harmonic constants or tidal differences": these are the reiterated phrases in various Admiralty publications. The authorities threaten in fact to withdraw non-harmonic information eventually.

The Admiralty at present publishes two volumes of Tide Tables. Part I, which appears yearly, contains the predicted heights and times over a period of twelve months for all the Standard Ports of the world. Formerly it was the custom to derive the information for lesser ports by means of a system of differences from a centrally placed Standard Port, but the tendency at present is to embrace all ports frequented by larger vessels into the list of Standard Ports. The number of ports for which this information is given tends therefore to increase as more tidal observations become available.

There remain however numerous ports for which the information is better given in the form of harmonic constants than as differences from a Standard Port. In Part II therefore will be found the full list of harmonic constants as far as MS_4 for all ports of the world from which records have been analysed; Part II is published every five years. It contains, further, instructions for the prediction of tides to a close approximation, though it should be realized that the attainable accuracy is not so high as in the predictions which form Part I of the tables. In these latter predictions a large number of overtides (family M_4, M_6, . . . etc.), and compound tides (family MS_4, etc.), making perhaps up to thirty constituents in all, are set on a machine in the Tidal Institute at

Liverpool; the machine is driven electrically and in the course of a few hours supplies the predicted tides for the whole year. Where however such predictions are not available, the approximate method of computation, employing some nine constituents, should be used in preference to non-harmonic reckoning.

Nevertheless the procedure is not yet in any general use in the Mercantile Marine. During the dreary homeward passage across the Southern Ocean from Adelaide to Durban I endeavoured to introduce the harmonic method to the Master of a certain cargo-carrying ship. The fascination of the constants and the variety of conclusions to be drawn from them was so great that the Captain eventually spent the greater part of a day in computing twenty-four hours of tide at Durban for the probable day of our arrival. Many sheets of paper were covered, and at length a tidal curve was produced. The prediction was for some day when the moon was in the first quarter and the other elements so disposed as to give a tide widely different from that to be forecasted by the use of the time of the moon's transit and the Establishment of the port. The times came out exactly as given in the full predictions for Standard Ports published in the more recent Part I of the Admiralty Tables. The Second Mate, who spent his watches below in writing a Treatise on Navigation, was on the bridge at the time: the Captain, delighted, ran up to interest the Mate in the excellence of the method. That officer, accustomed to checking other people's calculations, promptly noted that his senior's figures gave a foot more water than the published prediction. Now ships of the . . . Funnel Line are mostly of great draught, and Durban has a shallow bar: that a computation recommended by the Lords Commissioners of the Admiralty to be within a few tenths of a foot in precision should err by so much as a foot, and that in the dangerous direction of indicating more water on the bar than was actually the case, was extremely serious and might indeed have caused the loss of a ship. We found eventually that there was a misprint in the current (4th) edition of the Tables, Part II (1927): it was true that a 1929 supplement corrected the mistake, but it was impossible that the supplement should have reached the ship by that time. A_0 for Durban is given as 3·9 instead of 2·9. But when at length all this had been discovered, the Captain had said "Never again." Thus it was that Harmonic Constants were lost as a subject of conversation for the remainder of the voyage.

[*Note by Editor G.J.*—We must not omit our thanks to the Director of the Liverpool Tidal Institute, who very kindly undertook to compute at his Institute for a modest fee the tidal observations made by the Great Barrier Reef Expedition, and to deduce the constants published above.]

OLD RIVER-BEDS IN THE FENLANDS

MAJOR GORDON FOWLER

THE following brief account describes certain extinct waterways which I have noted in the Fens and which are now being studied in closer detail. As they have not been previously recorded their geographical and geological importance may be considerable.

Roddons

There are numerous raised banks of laminated silt or shell marl meandering through the Fens. Neither historians nor geologists appear to have noticed them, though both have paid considerable attention to recently extinct rivers such as "The Old Croft" in Littleport Parish, Isle of Ely, and "The West Water" on the boundary between Huntingdonshire and Cambridgeshire. Archaeologists have referred to "Rolls Lode," which in places forms the parish boundary between Ely and Stuntney. Fen dwellers however have noted these banks but generally without realizing their origin. They call them *roddons*. This word appears to be allied to *roddin* or *rodden*, which Wright in his 'English Dialect Dictionary' (vol. v, p. 139) gives as meaning a narrow road, path, or sheep track. I spell the word *roddon* as it sounds; and I prefer it as a spelling to *rodham*, as used in the name Rodham Farm, as the latter appears corrupted in the second syllable.

The raised position of roddons is due to differential shrinkage. According to investigations, not yet complete, I am led to believe that the peat of the fens has been shrinking during the last hundred years of intensive power-plant drainage and cultivation at the rate of about one inch per year, and about one-quarter of an inch per year during the previous two hundred years of windmill drainage. On the other hand the silt or shell marl beds, now prominent as the old waterways, have not shrunk nearly as much. The top of a roddon, provided the remains of its banks have been ploughed down, as is generally the case, now represents approximately the bottom of the waterway in the last stage of its existence (Fig. 1, *a*). Since then the shrinkage of the peat below its banks and immediate flood plain have caused the banks to subside until, helped on no doubt by the ploughing, a convex in place of a concave section is now presented on the surface (Fig. 1, *b*). Roddons, if large, may cut a channel into the clay which generally underlies the peat (Fig. 1, *c*); whilst, if small, they rest on its surface only (Fig. 1, *b*). I am indebted to Professor O. T. Jones and to Mr. J. M. Wordie for their co-operation in arriving at the reason for the convex appearance of roddons at the present time.

As roddons interfere with the cultivation of the land farmers generally endeavour to plough them down. In consequence it is only the larger and more recently extinct ones which show any signs of banks. As a rule therefore it is only in old grass land that they appear to the eye as resembling river or stream beds. In arable land their meandering courses are often very difficult to trace unless they happen to be the relics of waterways of some magnitude. Air photographs however if taken under favourable conditions, may show up even the smallest. (Plate 1 shows a roddon along the boundary of the parishes of

Hilgay and Welney, Norfolk.*) The dark line in the centre of the roddon which is so conspicuous in the air photograph is not visible to an observer on the ground. It may be due to shadows thrown by a very slight cavity at the top (see Fig. 1, *b*, *c*). On the other hand it may be due to traces of peat (which cultivation has mixed with silt) which formed in shallow and stagnant water after silting up or diversion had extinguished the stream and before differential shrinkage had made much progress.

Owing to their high-and-dry position roddons are much favoured nowadays

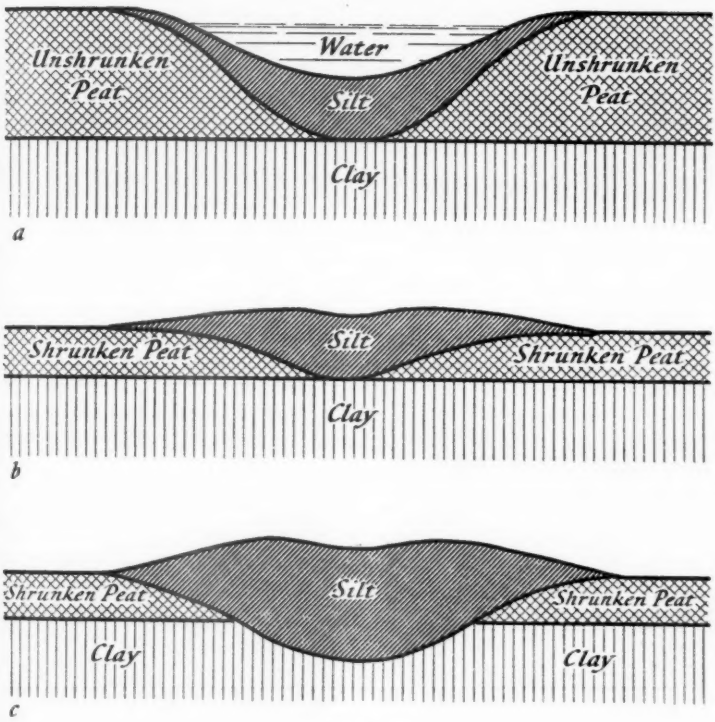


Fig. 1

for the sites of houses. Variations in the growth of crops occur on roddons and especially where their old banks have not yet been ploughed away. Where dykes cut through large roddons the sides of the former are apt to fall down unless supported by piles (Plate 2: roddon crossing Mile End Road, Littleport,

*See Professor Melville Jones's and Major J. C. Griffiths's 'Aerial Survey by Rapid Methods,' p. 33 (Cambridge University Press 1925). This and other air photographs from the same source are now in the possession of H.M. Ordnance Survey Office, Southampton. The roddons shown on them were not noted as extinct waterways until I pointed them out.

Isle of Ely), and it is said that in such places eels are far more numerous than elsewhere.

One of the largest roddons so far discovered is seen to advantage at Rodham Farm about 2½ miles north-east of March, Isle of Ely. The curious laminations of its silty structure are exposed in a pit just east of the farm cottage and are at present under examination. This roddon stands about 8 feet above the surrounding fenland and measures about 70 yards across its curved surface. The seventeenth-century historian, Dugdale ('History of Embanking and Draining,' 2nd edition, p. 174), and other observers since his time, seem to have confused this particular roddon with an ancient gravel track, some 8 yards broad, which follows its north side for some distance, and the south side of another similar one near Nordelph in Norfolk. This track was probably made in Roman British times. Roddons evidently represent the natural drainage of the Fens.

Old Runs

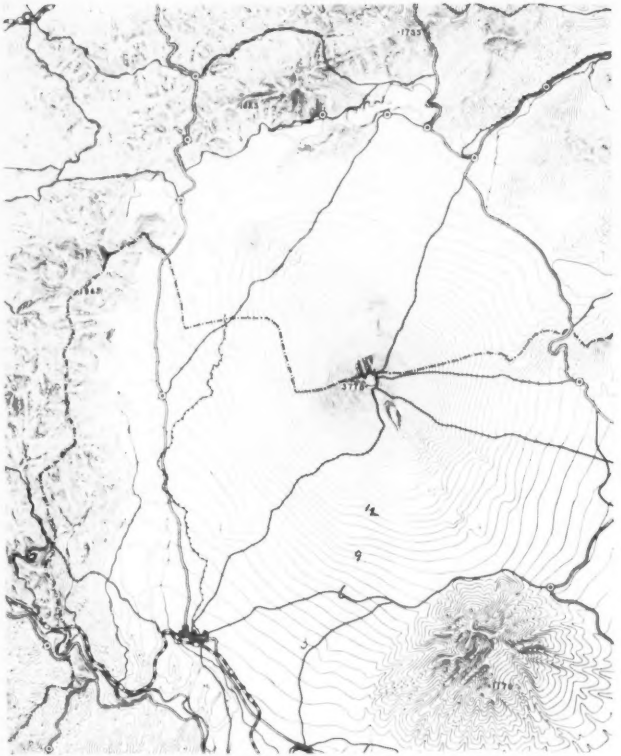
Another type of extinct waterway is known as an *Old Run*. These old runs are well known to fen people engaged in digging deep drainage dykes or trenches for clay, and it is these workers who first pointed them out to me. Old Runs appear as deep steep-sided channels in the clay that underlies the peat in most places. They are now full of buttery peat (Plate 3 shows an Old Run crossing the 10-foot drain Southery, Norfolk). In places their meandering courses can be traced by slight depressions in the present land surface due to the greater thickness in them of peat subject to shrinkage, and by variations in the growth of crops due, no doubt, to the greater moisture which their presence provides. They appear to have originated before the peat was formed at a time when the fall to the sea was probably greater and the sea itself farther away than at present.

A map showing the Roddons and Old Runs of the Fens is in course of preparation. This will be coupled with an attempt to outline their history by means of archaeological finds on the site of their banks or in their beds and, as far as roddons are concerned, by an examination of early historical references to the neighbourhood—some of which, I venture to believe, can only be made intelligible when the courses of the contemporary waterways are correctly known.

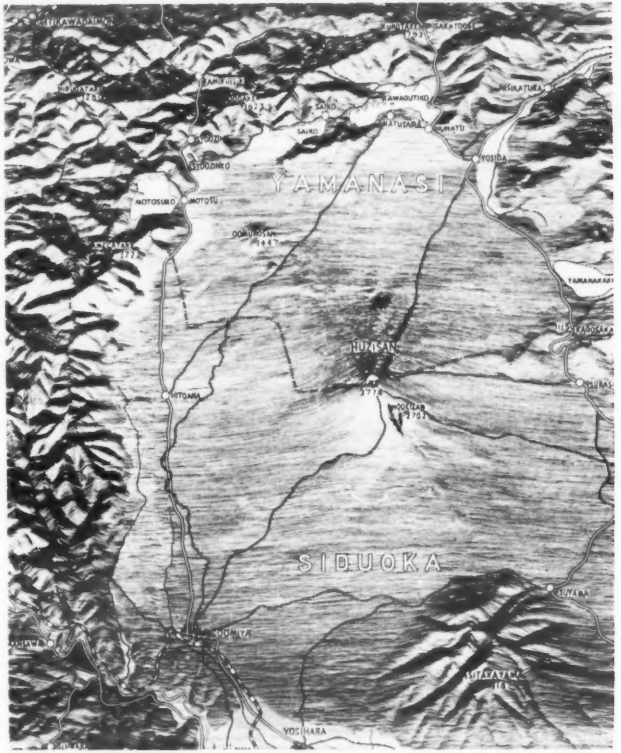
1. Air photograph taken at about 10,000 feet showing (A) a roddon, (B) the shell marl of an extinct mere

2. Roddon crossing Mile End Road, Littleport, Isle of Ely

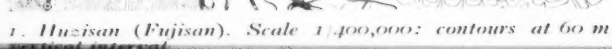
3. Old Run at Southery, Norfolk



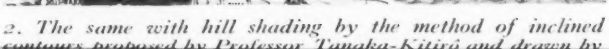
1. Huzisan (Fujisan). Scale 1/400,000: contours at 60 m. vertical interval



2. The same with hill shading by the method of inclined contours proposed by Professor Tanaka-Kitirô and drawn by



1. *Huzisan (Fujisan). Scale 1/400,000: contours at 60 m. vertical interval.*



2. *The same with hill shading by the method of inclined contours proposed by Professor Tanaka-Kitiro and drawn by*

THE ORTHOGRAPHICAL RELIEF METHOD OF REPRESENTING HILL FEATURES ON A TOPOGRAPHICAL MAP

TANAKA KITIRÔ, Assistant-Professor in the College of Engineering, Kyushu Imperial University

THE methods of representing hill features on a map may be divided into two classes, namely, the conventional and the natural methods. The methods which may be called conventional lay stress on imparting exact topographical information, and accomplish this by means of conventional signs. Maps and charts representing topographical features by contours, the layer system, or spot heights, belong to this class. The methods that may be called natural attach weight to the relief effect of the map in order to make the observer easily understand what the grounds represented look like. Maps delineating topographical features by brush-shading, hachuring, etc., belong to this class.

The natural methods hitherto employed afford rather disappointing results because although they aim at a delineation that is true to nature, they ignore realities, the theories upon which they are based being often conventional, and because the drawing involves some difficulty and a great deal of estimation on the part of the draughtsman. The fact that these defective methods are still in use to a considerable extent in many countries suggests the need of an improved natural method. To meet this need the author has devised a natural method of map delineation which, owing to its special characteristics, he has named the Orthographical Relief Method.

The natural method herein described is, like all other natural methods, based upon the principle of shading. In working out this new method however, the author has investigated theoretically the intensity of light and shade or the configuration of brightness on a surface and found a way of correctly representing on a map the brightness thus determined, justifying his view that the reasoning of the investigation should be based on realities and that the method of drawing should be as scientific as possible, so that the resulting map may be exact and true to nature. The author believes that the method which he has devised fulfils the requirements of a natural method with greater exactness of workmanship and effectiveness of result than any such method yet devised.

The first thing to be investigated is the exact configuration of brightness of the ground surface. As there is a great variety of ground surface there are correspondingly innumerable reflection ratios. For the representation of relief however it is hardly worth while to consider these varieties minutely. The ground may be assumed to be made up of an ideal material, having a constant reflection ratio throughout and perfect diffusibility. That being the case, it can be shown by the theory of photometry, as the author has deduced, that the brightness of any elementary surface of the ground, as seen vertically downwards, is proportional to the cosine of the incident angle of the ray of light for that elementary surface.

Starting from the law of brightness just stated, and assuming an oblique illumination, the author has arrived at the formula given below. Referring to the annexed figure, we may assume that the altitude of the sun is 45°, and that the incident rays are parallel to the X–Z plane. Then, knowing γ, the inclina-

tion or dip of the elementary surface P, and the direction of the inclination θ, the brightness B of the elementary surface relative to the maximum brightness on the whole surface can be obtained from the formula:

$$B=(\sin\gamma\cos\theta+\cos\gamma)/\sqrt{2}$$

The problem that next comes up is how to delineate exactly on a map the brightness thus determined. To solve this problem, the author devised a special line which he will refer to as an *inclined contour*. An inclined contour may be defined as the projection upon a datum plane of the outline of the intersection of the ground surface with an inclined plane, while the ordinary contour line (the isohypse)—which, to distinguish it from the inclined contour just referred to, may be called the *horizontal contour*—is considered to be the projection upon a datum plane of the intersection line of the ground surface with a horizontal plane. The author assumes the inclination of the inclined plane to be 45°, in accordance with the altitude of the sun previously stated. If contours determined in this way by several equidistant inclined planes are traced out on a map, the resulting inclined contours will appear as a sort of light and shade, since in accordance with the undulations of the ground surface the lines will be closer together in some places than in others.

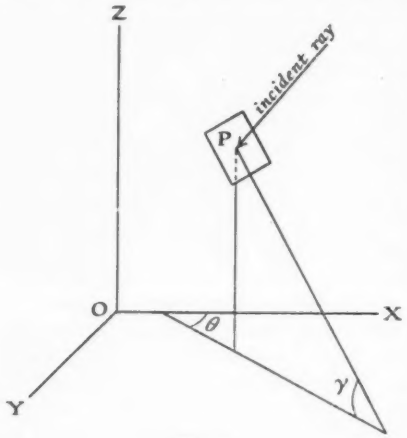


Fig. 1

An attempt was made to represent the thickness of these inclined contours by a mathematical formula so as to make the configuration of the brightness of the map correspond precisely with that of the ideal surface of the ground. To apply this refinement to the actual drawing however would be impracticable, if not impossible, since it would be necessary to change the thickness of the inclined contours for every inclination and every direction of the inclination of the ground surface. It was decided therefore, for the sake of simplicity, to take the thickness of the inclined contours as constant, the effect being almost the same, if the constant value of the thickness is properly determined. Detailed calculations show the constant value of the inclined contours that affords a configuration of brightness nearest to the theoretical one to be $0{\cdot}36d$, where d is the distance apart of the inclined contours on a level plain and may be designated as a standard distance for the inclined contours. Further calculations show that, on ground surfaces commonly met with, the application of the constant value of the thickness just determined results in less than 20 per cent. of error in the relative brightness of the map as compared with that of the ideal surface. Hence it will be seen that the simplified method of drawing is accurate enough for practical purposes.

In reading this map it should be noticed that the shapes of the inclined

contours suggest the perspective appearance of the outline of the hills, and that the continuous lines of these contours running close together and nearly parallel to one another give life to the map. And it may be perceived also that these facts, operating together with the exact delineation of the light and shade, contribute to intensify the effect of the relief appearance, which depends upon the density or number of inclined contours to the centimetre. The author wishes to suggest, according to the experiments he has made, that the mean number of inclined contours should be between thirty and seventy lines to the centimetre. This mean number coincides with the number deduced from the theory of vision.

It should be added that the proposed method differs from the so-called *relief gravure* method. It is indeed impossible to apply relief gravure to cartography, since that method requires a metallic model of the ground to be delineated, and since the final drawing obtained necessarily involves horizontal shifts in the respective positions of the topographical features, the extent of the shifts being proportional to the elevations of the respective positions. The orthographical relief method proposed by the author is entirely free from any such limitations.

The process of drawing by the proposed method may be explained in connection with the specimen of the orthographical relief map entitled "Huzisan and Hakoneyama" herein presented. In the first place, a horizontal contour map drawn from two to four times the ultimate scale should be prepared. This horizontal contour map is the basis of the orthographical relief map which should be drawn directly upon it. In our example, a horizontal contour map, 1/100,000 in scale and 60 metres in horizontal-contour interval, was drawn with necessary generalization from the 1/50,000 topographical map of the Land Survey Department of Japan. The horizontal contour map herein shown is the one thus obtained reduced to 1/400,000.

Next consider an inclined plane cutting the datum plane at the lower border of the map, the inclination or dip of the inclined plane being 45° toward the lower border. The horizontal contours of the inclined plane just considered should form a system of parallel straight lines, having consecutive distances on the map equal to the vertical interval of the horizontal contours for the sheet, and running parallel to the lower border. In this example the distances of these straight lines were taken as 0·6 mm. in accordance with the horizontal-contour interval of 60 metres for the horizontal contours representing the ground surface. These distances must also coincide with the standard distances of the inclined contours. These parallel straight lines should be drawn so as to cover the whole area of the map, since the orthographical relief map is to be drawn by means of the two systems of horizontal contours, *i.e.* the parallel straight lines of the inclined plane just drawn and the horizontal contours of the ground previously drawn. These two systems of horizontal contours should be drawn in colours (blue and pale red, for example) which are invisible on a photographic plate, since these two systems of lines should not appear on the finished map, and since the fair drawing is to be reduced to the ultimate scale by photography.

The preparation having been completed by the above operations, we can now begin the drawing of the inclined contours. By connecting consecutively

with a pencil line the points of intersection of the two systems of horizontal contours which are at the same elevations, we obtain an inclined contour. Now, the parallel straight lines represent on the map not only a single inclined plane but also a system of parallel inclined planes placed at equal intervals, each straight line being supposed to be the lowest horizontal contour of its own inclined plane. Consequently, by proceeding as before, we shall obtain as many inclined contours as there are parallel straight lines. The pencil lines obtained in this manner are then inked with a crow-quill pen in black. The thickness of the inked lines should be kept at the constant value of $0{\cdot}36d$ as determined by the theoretical investigation. In this example, since the standard distance of the inclined contours d is 0·6 millimetre, the thickness becomes 0·22 millimetre. Other details being plotted in black, the fair drawing may be reduced to the ultimate scale ($\frac{1}{4}$ size in this example) by photography, and the map reproduced, for example, by zincography.

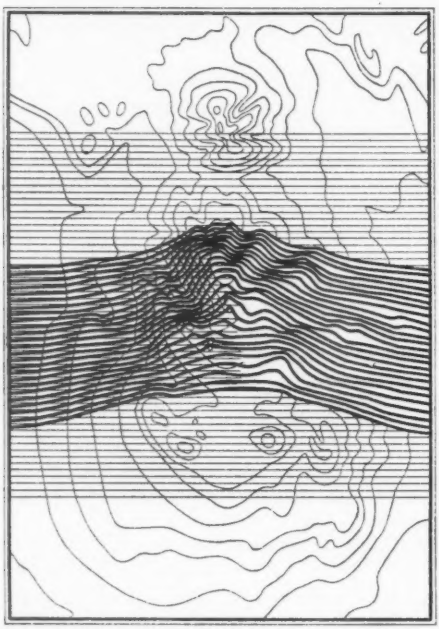


Fig. 2. Construction of inclined contours: Scale 1/100,000; contour interval 100 m.; therefore parallel lines ruled at interval 100 m. on scale of map or 1 mm. Inclined contours drawn with lines 0·36 mm. broad. The parallels and contours have been cleared from the right-hand half of the area to show the final results

The chief merit of the proposed method of drawing lies, as has been seen, in its simplicity and exactness of operation, dispensing as it does entirely with the need of a working scale, a colour scale, or any kind of estimation on the part of the draughtsman. The truth of this statement may be ascertained from the fact that the method comprises only one factor which is accomplished in a single operation: the tracing by definite reference points of the location, and location only, of the inclined contours with a pencil, and the keeping of the thickness of the inclined contours constant in tracing the pencil lines with a pen afterwards. Such matters are neither simply nor accurately accomplished in the natural methods hitherto employed. In the case of hachuring, for example, four factors—the spacing, direction, length, and thickness of each stroke—must be cared for at the same instant, while the draughtsman is obliged always to consult a working scale.

In short, the proposed method is rigorous in theory, scientific and easy in the process of application, and entirely free from ambiguity. The results are therefore uniform and the delineation of the topographical features is exact. The exactness of delineation may be easily recognized if the proposed map is compared through a magnifying glass with the reduced horizontal contour map herein shown, from the original of which the proposed map was made.

There is little need of emphasizing the importance of the fact that the geological or physiographical features characteristic of a region should be correctly delineated in a topographical map of that region. And, since the proposed method meets well this requirement, as will be seen by the explanation described below, the method is particularly adapted to works on physical geography.

The region represented by the map herein presented is situated in a fissure, called by Edmund Naumann a *fossa magna*, running north and south and cleaving the middle part of the Main Island of Japan. It is believed that this region was under sea-water in the tertiary period, having undergone several geological changes. Toward the end of the tertiary period, it was raised to land. The volcano Asitakayama that stands in the south of the region made its appearance at that time. At the beginning of the quaternary period the central part of the region, the part now occupied by the volcano Huzisan, subsided and at the same time left mountain ranges on the west, the north, and the north-eastern margins of the central part of the region. The mountain ranges formed in this way are the so-called pseudo-circus of the present Huzisan. The volcano Hakoneyama in the south-east of the region was formed at that time. The volcano Huzisan erupted last, its activity continuing until the historical age.

The geological history being known, it is an interesting study to investigate the physical geography of the region and to compare the results of the investigation with what the proposed map indicates. Asitakayama, being an old volcano, has been greatly dissected, and is now in its full mature stage. The radial valleys have been much developed, and one of them, running toward the south-west, seems to have started from the old crater. The pseudo-circus of Huzisan, made up mainly of tertiary strata, has been maturely dissected, since it has undergone denudations for a long period, so that the valleys are complicated and the peaks are angular. The valley of the Huzikawa river running from the north toward the south at the west end of the region is an erosion valley. This valley offers facilities for communication, a road and a railway having been constructed along it. A great valley running from lake Yamanakako toward the north-eastern corner of the region is a fault valley. The caldera of Hakoneyama, noted for its hot springs, is believed to have been originally an aspite. It has now been maturely dissected and the radial valleys have been considerably developed. Huzisan (Fujiyama) is a typical konide in its young stage and its slopes have been scarcely dissected at all by radial valleys. The profile of the mountain presents the shape of a logarithmic curve and its graceful outline has given it an international reputation. On the summit is a circular crater of comparatively small diameter, and near by, to the south-east of the summit, lies an explosion crater of the hill of Hooeizan, active in 1707.

On the mountain-side of Huzisan are scattered numerous parasitic cones of which the hill of Oomurosan on the north-western slope is the largest. The Five Lakes of Huzi, from Motosuko to Yamanakako inclusive, are blocked waters formed by the eruption of Huzisan, and indeed some of them have been separated into two by a lava flow in the historical age. The waters of the lake district are believed to have flowed toward the Bay of Surugawan through the tributaries of the Huzikawa, which run along the western outskirts of Huzisan. These tributaries however have been beheaded by volcanism, and the waters of the lake district now flow toward the north-east through valleys in the pseudo-circus.

It should be noted that the physiographical features mentioned above are depicted prominently in the proposed map. In this respect the author's map seems to compare well with the bird's-eye views or block diagrams commonly drawn for the purpose of explanation.

The advantages of the orthographical relief method are:

(1) Maps drawn according to this method afford the observer the visual sensation of relief he would get from looking at models. Hence the maps afford at a glance a clear idea of minor features no matter how complicated they may be, to say nothing of the general character of the country.

(2) In respect to minuteness and exactness of delineation, the proposed maps compare well with horizontal contour maps, the proposed maps being after all a kind of contour map.

(3) The process of drawing is simple and scientific, and involves no ambiguity.

The disadvantages of the method are:

(1) Maps drawn according to this method do not tell the definite elevation of any point on the map—a disadvantage inherent in all natural methods. This drawback of the proposed method may however be remedied to a certain extent by means of spot heights scattered over the map.

(2) The maps are generally too dark. It is unavoidable, whatever the method of cartography, that the more minute the representation of topography the more filling in of the map is necessary. The map may be more or less lightened however by printing the inclined contours in colours.

To summarize what has been said above, the proposed method of hill delineation is particularly adapted to fill the requirements of physiographers and landscape architects and to meet the demand for maps of comparatively small scale and general use, guide maps of any scale, and the like.

[*Note by Editor G.J.*—It has not been possible to do full justice to the very interesting specimens of his results which Professor Tanaka Kitirô has sent with this paper. The originals are preserved for study in the Map Room. The small pieces of the two maps here reproduced side by side for comparison, on the original scale, have lost much in reproduction, but may serve to give a rough impression of the method. The drawing on the new principle is made to represent light from the south. We are accustomed to a north-west light in such representations, and are likely to appreciate the result better if the plate is turned 135° clockwise. The effect on the steeper broken ground about the base of the central volcanic cone is then excellent. The cone, on the other hand, which is less steep in its lower slopes, looks almost flat by comparison: at least at first

sight; but the representation improves on closer study. It is evident that the process cannot be judged by a black-and-white example: the method should be used in making a plate which is to be printed in grey or buff. Since the parallel lines which are the base of the construction are drawn at a distance apart equal to the vertical interval on the scale of the map, *e.g.* at 1 mm. for 100-m. contour interval on a 1/100,000 map, it is clear that most topographical maps must be enlarged before a shading plate can be drawn by this method. It is clear also that the draughtsman must have some specimens to guide him in drawing his inclined contours among sinuous horizontal. The method requires study and experiment, which so interesting and novel an idea will certainly receive.]

A SUBMARINE TROUGH NEAR THE STRAIT OF GIBRALTAR

J. W. GREGORY

ADMIRAL H. P. DOUGLAS has kindly called my attention to a submarine trough on the coast of Morocco between Tetuan Bay and Ceuta. It was discovered owing to one of H.M. ships having lost her anchor and cable when anchoring beside it. It was surveyed in 1912 and is shown in Admiralty Chart 142. The trough indents the 100-fm. shelf about 7 miles south of Ceuta and 6½ miles north of Cape Negro; it ends 2 miles off shore from a slight promontory on the coast (at 35° 46′ N.) marked in the Admiralty Chart as Tunny Point. The 100-fm. line, after running parallel to the shore and about 5 miles distant from it, makes a sudden bend from north-north-west to west-south-west, which it keeps for 1¾ miles. The trough is slightly over a mile wide. The adjacent shelf is mostly between 20 and 60 fm. deep. The trough sinks abruptly to depths increasing seaward from 120 to 175 and 224 fm. The number of soundings is insufficient to show its form and cross-sections; but it is clearly steep-sided and the best cross-section shows a fairly flat floor.

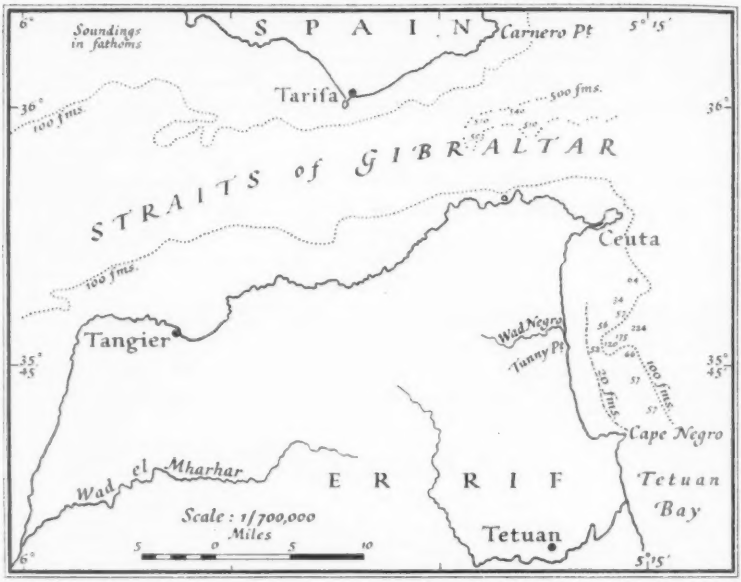
The central line of the trough trends about 32° north of east or about north-east by east. The Spanish coast from Tarifa to Cape Carnero and the main deep along the Strait of Gibraltar north of Ceuta both trend about east-north-east. The geological maps of the area* do not indicate any faults in line with the trough; but the low floor of the valley of the Wad Negro, which runs inland opposite the trough, is in line with the long tract of alluvium on the floor of the Wad el Mharhar, which reaches the western coast. This trend is seen in many of the geographic features of the Tangier–Ceuta–Tetuan peninsula.

The occurrence of this trough in the coastal shelf of the Mediterranean, in agreement with that on the eastern coast of Cyprus (cf. *G.J.*, vol. 78, 1931, p. 357), is of interest in connection with the recent paper by Mr. F. P. Shepard† advocating the glacial origin of such troughs on the ground that they occur only on glaciated coasts. He recognizes the existence of submarine river-cut valleys

*"Mapa Geologico de la Peninsula Norte-Marroquí 1–200,000. Detroit de Gibraltar." Instit. Geol. España 1926, opp. p. 186. "Mapa Geologico del Estrecho de Gibraltar," in Lieut.-Col. Pedro Jevenois's 'El Túnel Submarino del Estrecho de Gibraltar,' Madrid (1927).

†"Glacial Troughs of the Continental Shelves," *Journ. Geol.*, xxxix, 1931, p. 347.

and rift valleys; but he holds that as shelves off glaciated coasts have an abundance of these troughs and shelves off unglaciated coasts lack them, their origin would seem to be connected with glaciation. Mr. Shepard lays down four distinctions between submarine troughs of glacial and of non-glacial



origin. The trough south of Ceuta agrees so well in its form and its abrupt western end with the deep in Gibraltar Strait below the 500-fm. contour, that the two submarine valleys are probably of the same origin; they cannot be glacial, though their characters are those which Mr. Shepard assigns to the glacial troughs. The similarity of these troughs off glaciated and unglaciated coasts is an argument in favour of their tectonic origin.

REVIEWS

EUROPE

REGIONAL PLANNING REPORT ON OXFORDSHIRE. By the Earl of Mayo, S. D. Adshead, and Patrick Abercrombie. *London: Humphrey Milford* 1931. 10×6 *inches;* xx+80 *pages; illustrations and maps.* 10*s* 6*d*

Oxfordshire, with its bizarre outline, with its great variety of geological outcrops and consequently of scenery and architecture, and with an important river forming the whole of its southern boundary, may not at first sight seem to be a geographical unit suitable for a regional plan. The distinguished authors of this Report divide the county into no fewer than ten regions, and furthermore consider that the Cherwell valley which bisects it marks the beginning of the West of England. It certainly does not require a trained eye to appreciate the essential differences between villages like Thame and Burford, or between structures like Sonning Bridge and New Bridge. But, as Major Muirhead in his foreword observes, there is still such a thing as County sentiment in England, and places so different in character as Henley and Chipping-Norton can still share a common loyalty; in other words, human geography can hold its own against physical geography.

It cannot be denied that in a County so largely agricultural and purely rural as Oxfordshire there are no areas specially liable to violation of the amenities except the City of Oxford and the Thames Valley; and of these two the first has its Preservation Trust and the second its Branch of the C.P.R.E., whose admirable Survey compiled by the authors of this Report was noticed in *G.J.*, vol. 77, p. 71. But the great industrial growth of Oxford has far-reaching effects. There is a very interesting map showing the residential distribution of workers from two prominent undertakings with some surprising figures not only in adjacent villages (Garsington 103, Littlemore 89, Wheatley 83, etc.) but also in the more distant towns (Abingdon, Berks, 242, Witney 112, Banbury 90, etc.). All this means additional housing and transport, with the growing menace of ribbon development along roads and the urgent need of by-passes to relieve traffic congestion, which is well shown in another of the informative maps. The authors, as usual, have much sound advice to give on these and other matters in the Survey and General Recommendations of Part I and in the Particular Recommendations of Part II. But need they have coined the dreadful word "Rurbanization"? This is the only blot on a well-printed, well-illustrated, and well-mapped volume.

J. H. R.

THE GEOGRAPHY OF LONDON RIVER. By Ll. Rodwell Jones. *London: Methuen & Co.* 1931. 11×9 *inches;* x+184 *pages; diagrams and maps.* 21*s*

There was undoubtedly room for a detailed analysis of the physical factors in the evolution of the Port of London; but whether this book has filled the gap is open to question. The more general aspects of the physical geography are familiar to all, and Professor Rodwell Jones has well brought out a number of ways in which they have influenced the history of the port. A good example is his discussion of the rise and fall of Gravesend: here the deep channel of the Thames estuary makes contact for the last time with land well above flood-level, and the width of the river was within range of early cannon. Before the days of steam all traffic above Gravesend was carried up and down by the tide; below that point a favourable wind was essential; consequently it became a regular stopping place, both inwards

and outwards, and many vessels took on their full crew and provisions there. It is also shown how the position of the town at a node where the river is easily accessible by road from south and east Kent gave rise to the "Long Ferry," by which passengers continued the journey to London by water. The fall of the town came with the development of steam, by which vessels became to a large extent independent of wind and tide. Rochester is treated in a similar way, as are the "bluff" towns of Greenwich, Woolwich, Erith, Northfleet, Purfleet, and Grays, all situated at points where the river touches solid rock and comparatively high ground.

On a smaller scale the influence of the shallows in the navigable channel and of the shoals at the mouth of the estuary is traced. It is interesting and useful to have exact charts of these at various dates collected and reproduced for comparison. In the account of the canals which fed the Port of London the statement that the navigation to Guildford was closed in 1868 is apparently due to ungrammatical writing rather than actual error, but there is no mention whatever of the Croydon Canal, which brought a considerable traffic in stone from Reigate; the reopening of the canal to Aldershot during the war might also have been mentioned.

Misprints and bad grammar and punctuation are specially numerous in the first three chapters, an unfortunate distribution, as it is apt to prejudice the reader. On the other hand a large amount of information on the history of the docks and the trade, as well as on the subjects noticed above, has been brought together. The book will therefore be useful to those who do not care to delve in blue-books and reports of committees for themselves; but the results might well have been condensed and adequately published in the form of a paper in a journal rather than in a book costing a guinea. C. N. B.

A COTSWOLD BOOK. By H. W. TIMPERLEY. *London: Jonathan Cape* 1931. 8×5 *inches;* 256 *pages; drawings by* L. S. LOWRY. 8*s* 6*d*

These are the word-pictures of a nature-lover but not very much else. As he wanders down the Cotswold trackways he loves to distinguish the notes of different birds and the greens of grasses and trees. This sort of thing continued for scores of pages will be enjoyed by some readers but found rather cloying by others. Many villages are visited, but there is very little description of particular buildings; the churches, except so far as their towers may form a feature in the landscape, are practically ignored. The author is more interested in garden-warblers and the lesser bindweed. Yet it would be difficult to better his summing up of Cotswold architecture as "flexible enough to contain the simple cottage as well as the large house without revealing a trace of condescension in the one or of pompousness in the other," or his appreciation of Cotswold stone: "There is no flinty hardness in either its feel or appearance; it is limestone, but not the limestone that is quarried in wild rugged hills. By their look the smooth slopes from which it is taken could no more cover a stone of intractable hardness than could the downlands farther south. They are too serene." This passage makes all the more remarkable the conspicuous lack of softness and serenity in the illustrations. Their place might well have been taken by a few good sketch-maps. But the book has neither map nor index. J. H. R.

RUSSIAN WATERS. By NICHOLAS POLUNIN. *London: Edward Arnold & Co.* 1931. 8×5 *inches;* xii+306 *pages; illustrations and map.* 10*s* 6*d*

A journey (evidently fatiguing) in northern Lapland would be a sufficiently energetic programme for most people's Long Vacation; but when the Oxford University Expedition of 1930 ended at Tromsö on August 21, this undergraduate

proceeded to fill in the remaining weeks by signing on as deputy bosun in a British timber-ship bound for the White Sea. In spite of much hard work and rough weather he managed to keep this very complete diary, by far the greater part of which describes life on the ship, where he made friends with the crew and with the Russian loading gang. The book is well entitled; for only one day was spent on Russian soil. This was at Soroka on the Murmansk Railway, a place likely to increase in importance from its position at the end of a new waterway from the White Sea to the Baltic. The author ran a certain risk of being detained, if nothing else, by the Soviet authorities, as he could not disguise (except by Latin script and mispronunciation) the Russian name on his papers and had difficulty in concealing his full knowledge of the language. But this knowledge and his Russian connection lend special value to his observations on what he saw and heard. He gives an impression of a handful of genuine Communists dominating a population that finds it good policy to profess loyalty to Communism as that means more food and a better time generally—not that life in this bleak northern settlement can ever be much more than drab and meagre. The coming of winter in the White Sea is well described; the only redeeming touch of beauty appears to be furnished by the aurora borealis. The author returned in a Swedish ship to Antwerp and was only a few days late for term. The book is unconventionally written, with a special partiality for the word "pansy," and makes interesting reading; but there hardly seems enough solid matter in it to justify the high price. J. H. R.

BEITRÄGE ZUR GEOLOGIE DER WESTLICHEN MEDITERRANGEbiete. Edited by HANS STILLE. Nos. 2–8. (*Abh. Ges. Wissensch. Göttingen. Math.-Phys. Kl.*, N.F. XIV, 1, 2, XVI, 2, 3. III. Folge. Heft 1, 3, 5.) *Berlin: Weidmann* 1929–31. 10×7 *inches*. No. 2. Der geologische Bau des Katalonischen Küstengebirges. By WALTER SCHRIEL. iv+80 *pages*. No. 3. Stratigraphie und Tektonik des Keltiberischen Grundgebirges (Spanien). By FRANZ LOTZE. xiv+320 *pages*. No. 4. Die Sierra de la Demanda und die Montes Obarenes. By WALTER SCHRIEL. viii+106 *pages*. No. 5. Zur Tektonik der Keltiberischen Ketten. By C. HAHNE, G. RICHTER, and E. SCHRODER. 180 *pages*. No. 6. Betikum und Keltiberikum in Südost-spanien. By ROLAND BRINKMANN. viii+108 *pages*. No. 7. Zur Geologie des Tyrrhenisgebietes. By ROLF TEICHMÜLLER. vi+124 *pages*. No. 8. Das Paläozoikum der Spanischen Pyrenäen. By HERMANN SCHMIDT. iv+86 *pages*. *Diagrams and maps*. *M.*12, 30, 12, 17, 14, 12, 8

Professor Stille's collaborators in this series of Western Mediterranean studies have been working up till now mainly in the highlands of Spain east of the meridian of Madrid, as was natural from the special emphasis laid on Celtiberia in the editor's introductory monograph (reviewed in *G.J.*, vol. 74, p. 401). The general inference from the results of their work has been made by von Seidlitz, who refers to Celtiberia, in his recently published survey of Mediterranean geology, as a "mobile shelf" (on the eastern side of the Iberian Meseta), and the term, although used nowhere by the authors themselves, is obviously appropriate to an area such as they describe, affected by crustal movements intermediate in rhythm, character, and intensity between the foreland and Alpine types. During the earlier part of the Mesozoic era vulcanicity was as active here as in the neighbouring geosynclinals, from which Celtiberia is first clearly differentiated only in the Wealden epoch, and subsequent mountain-building movements, although in the foreland rhythm, repeat to some extent for the shelf area the whole bilateral process, as Professor Stille conceives it for Alpine areas, of outward migration of folds from median zones of comparative tectonic rest.

The topography of to-day arises therefore in the first place from the superimposition of a system (broadly speaking, Alpine in date) of lines of folding and upheaval and of median zones, on the earlier, Variscan system, Alpine in type, arising from the late Carboniferous movements. Since the lines of the later system give the contours of the mountain and hill-ranges, whatever the structure, discordance between the systems appears as discordance between Variscan structure and Alpine contour; this is particularly patent at the eastern end of the Sierra de Guadarrama where the structural lines cut the contours at right angles.

In the north-eastern and south-eastern corners of the Meseta the folds of the foreland shelf are in contact with the inward-directed folds from the geosynclinals. In the south-eastern corner, overlooking the Montesa valley, the Meseta has been invaded by Alpine folds of the Baetic system, and the fore-deep, which seems at first sight to have disappeared here from the Alpine front, is represented by a trough-like deformation of the Pliocene peneplane in the contact zone. More striking is the case of the north-eastern corner. Here the Pyrenean folds, wandering southwards with a certain amount of side-step, advanced at the close of the Miocene, in the Rhodanian phase, over the north-west corner of the Ebro basin, already disturbed by northward-directed movements at the beginning of the Miocene and covered subsequently by one continuous sheet of Miocene deposits. The effect of the Rhodanian movements was to raise the Montes Obarenes and the Sierra de Sobrón, breaking up the single basin into the isolated basins of Medina de Pomar, Miranda, and others, and the basin of Briviesca, still continuous with the main Ebro basin. Thus the vexed question of the gorges at Oña, Trespaderne, and elsewhere, by which the Ebro and its tributaries cut across the limestone sierras, receives a trenchant solution, since the courses of these streams are obviously both epigenetic and antecedent; on the earlier view of the date of the folding movements it was hard to see how they could be either. If the Rhodanian overthrusts, with an amplitude of some 6 kilometres, of the Montes Obarenes over the Miocene of the basin should be confirmed, a most notable contribution has been made to the geomorphology of the Peninsula.

The next step would appear to be to correlate the movements of the mobile shelf with those of the more stable area immediately to the west. The unimportance of Laramide and Pyrenean movements on the mobile shelf, considered in conjunction with the depth of over 1000 metres of Early Tertiaries proved by soundings at Alcalá de Henares, suggests that different rhythms may have been followed in the east and west of the Meseta; the rhythm in Catalonia differs apparently from both. Professor Stille's team seems however to be working eastwards, and the later monographs deal with the Pyrenees and with the Cor-Sardinian and Tuscan areas. So far as Spain is concerned it would be fair to describe the team as a brilliant raiding party, and their work as impressionistic in the best sense. If the party have left the Meseta, it will be a pity; the present writer had hoped to meet them there. He has learned a great deal from them, but he has one or two things to show them! R. A.

POLUOSTROV KANIN [THE KANIN PENINSULA]. By S. G. GRIGOREV. *Moscow: Association of Scientific Research Institutes at the Physico-Mathematical Faculty of the First Moscow State University* 1929. 10×7 *inches;* 472 *pages;* 2 *maps,* 36 *illustrations,* 6 *sketch-maps.* 5 *roubles*

Kanin is the name of that curiously shaped peninsula over 150 miles long that juts into the Arctic Ocean on the east side of the entrance to the White Sea. This volume, which unfortunately is not furnished with the summary in a Western European language that is so often found in Russian geographical publications, contains a history of its exploration and diaries of the author's own expeditions

in 1905 and 1913, and concludes with a bibliography, a short note on the accompanying large map (1 : 617,000), and a long list of plants collected at various times. It is hoped to publish a second volume containing the 1914 diaries, all the scientific results to date worked out, and a general geographical description.

The author admits that, although Russian settlers from Novgorod reached the White Sea in the twelfth century and were acquainted with its western and northern shores, it was the English and Dutch who put Kanin on the map. Anthony Jenkinson passed this way to Muscovy in 1557–61 and produced in 1562 the first map, "Russiae, Moscoviae et Tartariae Descriptio," to give Kanin by name. It appeared as "Kaninoz," that is "Kanin nos" (Russian for nose or ness), a term at one time given to the whole peninsula but now restricted to the cape at the north-western end of the long rocky ridge or Kamen, which the author considers to provide the probable derivation of the word Kanin. Barents followed in 1594–7 and gave his name to the sea on the north. It may be useful to note that Cheshskaya Guba, the name of the gulf on the east of the peninsula, means not Czech Gulf (as it might) but Chesha Gulf, being called after the river Chesha that flows into it from the narrowest part of the isthmus; the *e* in these words is written by the author *ĕ* to show that it is pronounced *o*. J. H. R.

DÄNEMARK, SCHWEDEN, NORWEGEN: Landschaft, Baukunst, Volksleben. By KURT HIELSCHER. *Leipzig: F. A. Brockhaus* 1932. 12×9 *inches;* xvi+vi+viii *pages* (*text*) *and* 291 *plates; map. M.*24

There can be nothing but praise for this admirable volume, a collection of collotype reproductions of some of the most successful and beautiful examples of landscape and architecture photography we have seen. Herr Hielscher combines an artist's vision with great technical skill, and his lighting effects and photographic angles are generally chosen with impeccable taste. To turn over the pages of his book is to wish to see every one of his subjects for oneself. Only occasionally the memory is imperfectly satisfied, as in the case of the castle at Vadstena, where the angle of vision gives too much importance to the end towers as compared with the main block of the building. The views of the Norwegian fjords and of the Lofotens are of outstanding beauty; though, as usual, Norway north of Trondheim is rather inadequately treated. Herr Hielscher has also produced a volume of photographs of Germany under the title of 'Deutschland,' which we have not yet seen, but understand to be of even finer quality than the present volume. The linen binding is strong and pleasant to look at and considering the quality of its contents the book seems reasonably cheap. D. C. S.-T.

WANDERINGS. By ARTHUR SYMONS. *London: J. M. Dent & Sons* 1931. 8×5 *inches; 292 pages; illustrations.* 8*s* 6*d*

SUMMER ISLANDS: Ischia and Ponza. By NORMAN DOUGLAS. *London: Desmond Harmsworth* 1931. 8×5 *inches; 80 pages; facsimile map.* 3*s* 6*d*

AND THEN TO TRANSYLVANIA. By HENRY BAERLEIN. *London: Harold Shaylor* 1931. 8×5 *inches; 254 pages; sketch-map.* 7*s* 6*d*

THE WANDERING GENTILE'S LOG BOOK (1929–1931). By RATHMELL WILSON. *London: John Davis* 1931. 9×6 *inches; 186 pages.* 5*s*

Mr. Symons as a travel writer is not so well known as he should be, for both 'Cities' and 'Cities in Italy' are subtle and remarkable books. Now, nearly thirty years after the first, he has brought out a third series of travellers' impressions under the apt title of 'Wanderings'; for more than most professional Wayfarers and Wanderers Mr. Symons is a born Wanderer, restless, disturbed, discontented, never happy unless on the move physically and spiritually. The notes here gathered together, some new, some reprinted from periodicals, were written

at dates varying from 1890 to 1925, and treat of places so diverse as Paris, Le Midi, Venice, Switzerland, Berlin, Kent, and Cornwall. But no sensitive reader can escape the conclusion that in all but hard physical fact the date and locality vary far less widely. Whether we are in Arles, Toulouse, or St. Ives, we seem never very far from the scent of London and Paris in the eighties and the nineties, from the Impressionists, the Symbolists, and the Decadents, the Café Royal and the Nouvelles Athènes. No other writer, not even Mr. George Moore, suggests so exactly the intellectual and social background against which, in fantastic silhouette, move the strange figures, now gay, now sinister, of Manet, Toulouse-Lautrec, Beardsley, Pater, Huysmans, and Verlaine. Mr. Moore, a far more individual and polished writer, though perfectly at his ease in these circles, spreads the veneer of his suave style and highly personal vision over his artistic friends, so that they seem no more than infinitely diverting characters in a drama of his own contriving. Nowhere is Mr. Symons more engrossing than when he traces the ever-changing dwelling-places of Baudelaire in Paris. But he is also capable of appreciating the calm and quiet of the English scene, and the range of his sympathies is further shown by so accurate a vision of the Atlantic coast of Galway as this: "As we drive seawards the stone walls closing in the woods dwindle into low, roughly heaped hedges of unmortared stones, over which only an occasional cluster of trees lifts itself; and the trees strain wildly in the air, writhing away from the side of the sea, when the winds from the Atlantic have blown upon them and fixed them in an eternity of flight from an eternal flagellation."

Perhaps after all it is a relief to turn from Mr. Symons's involved meditations to the open and natural Paganism of Mr. Norman Douglas. Scholar as well as pagan, he does not know if he is happier in investigating remorselessly the truth of a reputed classical site, or sunning himself after lunch on the easier slopes of the Italian hills. 'Summer Islands,' which consists of rambling notes on Ischia and Ponza, is not throughout his best work and has a little the air of having been pulled out from the bottom of an old drawer as a friendly gesture to a new publisher. But as a slight appendix to 'Siren Land' and 'Alone' it has its value and charm. After reading twenty pages of Mr. Douglas we begin to feel positively warm; and no one should miss the entertaining account of what happens when you order a hen for dinner on the island of Typhoeus.

Transylvania offers us a more primitive literary fare. Mr. Baerlein's artless conversations will be familiar to readers of his 'In Search of Slovakia,' and any one who was content to enjoy that book without inquiring too closely into questions of fact and fiction will be glad to go a little farther in the company of the author and his friends, the gypsies, peasants, and itinerant vendors of religious pictures.

With 'The Wandering Gentile's Log Book' we reach literary rock bottom, for it can hardly be possible to write more naively or publish more crudely than this. Every sentence begins a new paragraph, and the text is larded with parentheses, italics, and exclamation marks. Whether in Paris, at Oberammergau, or in his 'Hop through Holland,' the author can always be trusted to react in the expected manner. But it is not inconceivable that many people will enjoy his book, which has the merit of being direct and unselfconscious. D. C. S.-T.

ASIA

A PASSPORT TO CHINA. By LUCY SOOTHILL. *London: Hodder and Stoughton* 1931. 9×6 *inches;* xii+340 *pages; illustrations.* 21*s*

The period covered by this book is from 1884–1910, a momentous period in Chinese history. Mrs. Soothill has described with a singular restraint and charm

of manner the life of a missionary, first—and for a longer period—in Southern China, and later in the north. Although the book is not primarily of geographical interest, all who are interested in China will welcome so sympathetic a study of the Chinese, and especially of the more humble people. The authoress knew them better than all but a very few foreigners, and was all her life in very close touch with them. We read only occasionally of the Captains and the Kings who are mostly more prominent in literature, but of the common people we have a thorough and most exact study. One's only regret is that the authoress did not think it right to include a little more of the country, for she knew the flora well; a map would also have been helpful. L. H. D. B.

LOU-LAN: CHINA, INDIEN UND ROM im Lichte der Ausgrabungen am Lobnor. By ALBERT HERRMANN. *Leipzig: F. A. Brockhaus* 1931. 8×5 *inches;* 160 *pages; illustrations and maps. M.*7.50

The discovery of the buried town of Loulan and the elucidation of the topographical problems of the surrounding portion of the Takla Makan desert has been one of the major feats of twentieth-century exploration. Several expeditions have provided much material for geographers, geologists, archaeologists, and historians, but their conclusions have remained embodied in publications not readily accessible to the general reader. It is Herr Herrmann's purpose to provide a succinct, non-technical account of this fascinating chapter in Central Asian history. After detailing the incidents of its discovery from the beginning of the century down to last year, he narrates the advent of the Chinese in the second century B.C., and their efforts to maintain contact with Central and South-West Asia throughout the following five centuries, in the face of repeated Hun attacks. The route thus established formed an important trade artery of the ancient world, by which the Romans received silk and other exotic products, and by which Hellenistic and Bhuddistic cultural influences spread slowly eastwards. An interesting chapter contains translations of some of the fragments of documents found on the site, administrative and private correspondence, which throw a vivid light on the life of an ancient Chinese frontier post. The book is particularly well illustrated, and there is a short bibliography. G. R. C.

UNDER EASTERN ROOFS. By THEODORA EYTON-JONES. (*London*): *Wright and Brown* (1931). 9×6 *inches;* xx+300 *pages; illustrations and sketch-map.* 12*s* 6*d*

Miss Eyton-Jones has a facile pen and has written an entertaining and lively account of her experiences in the Near East. She was fortunate in having friends at Court, and the Orthodox Prelates, whom she had previously met at Fulham Palace, treated her with particular kindness. But besides being discursive her book must be said to be too self-assertive, and a few of the more intimate reminiscences might with advantage have been omitted. It can hardly claim any geographical interest, as the places visited have been described many times, and this is not the place to deal with its theological aspirations. A. W. S.

PLANT HUNTING IN THE WILDS. By Captain F. KINGDON-WARD. *London: "Figurehead" (Pioneer Series)* [1931]. 9×6 *inches;* 78 *pages; illustrations.* 2*s* 6*d*

In this little volume Captain Kingdon-Ward, who is a Gold Medallist of the Society and well known for his travels in south-eastern Asia, has given us several episodes from various wanderings in that remarkable and inaccessible region on the borders of Tibet, Assam, Burma, and Siam, to which he has made many expeditions in search of new plants. In the first episode he describes a visit to Yun-ning on the eastern borders of Tibet, where he was very well received and

obtained some valuable plants and seeds. Another chapter contains an account of the final solving of the riddle of the Tsangpo Gorges and the connecting link between the Tsangpo River of Tibet and the Brahmaputra of Assam. Although the river drops over 2000 feet in about 20 miles there are no great falls, as far as has been reported, but a series of raging rapids.

In the Mishmi Hills many new and lovely rhododendrons and primulas were discovered; but the plant hunter must first discover the plants when in full flower, and then wait until late autumn, when the hills are covered with snow and ruthless winds prevail, to fight his way through and gather seeds from the plants observed in the summer months.

The little volume is well illustrated with photographs taken by the author; the most remarkable of these is a view of a tubular rattan bridge which spans the Dihang river in the Abor hills of the Assam frontier; the bridge is 800 feet in length and hangs 50 feet above the river, and must be most alarming to traverse. The absence of a map of any kind makes it somewhat difficult to follow Captain Kingdon-Ward's routes, but the stories are well told and full of interest, though not perhaps of any great geographical significance. W. L. S.

THE SOUL OF MALAYA. By HENRI FAUCONNIER. Translated by ERIC SUTTON. *London: Elkin Mathews and Marrot* 1931. 9×6 *inches;* vi+248 *pages; illustrations.* 9s

M. Fauconnier's study of the Malayan scene, although presented in a fictional form, has little in common with the ordinary novel which deals with the tropics, and it is important not for its fiction, but for its truth; on the other hand, although the publishers have embellished the English version with some rather unnecessary photographs of Malayan scenery, it is far from being a book of travel. It is however an extremely acute estimate of Malay psychology, and as such it must inevitably take a high place in the bibliography of Malaya, quite apart from its rare literary qualities. These, as shown by a comparison with the original (which under the title of 'Malaisie' won the Prix Goncourt for 1930), have been sensitively rendered into English by Mr. Eric Sutton. It could have been no easy matter to translate the metaphysical disquisitions of Rolain, the enigmatical planter, who, with the narrator (also a French planter), is the medium through which the reader is allowed to see into the heart of the Malay. As an intimate realization of Malay character, with its wild terrors, hysteria, charm, politeness, indolence, and superstition, this book has not been surpassed. It contains many a shrewd aphorism as well, such as "In the East a man is never so thoroughly robbed as when he has taken precautions to protect himself." There speaks a man who knows the East. O. R.

LES NOMS DES LIEUX HABITÉS PAR LES CHINOIS EN MANDchourie. By TAGUCHI MINORU. *Paris: Jouve et Cie* 1931. 9×6 *inches;* 108 *pages*

There is evidence that the Chinese began to colonize Manchuria during the Han dynasty (206 B.C.–A.D. 221); but intense and systematic colonization did not set in till the Emigration Order of 1653 under the Ch'ing or Manchu dynasty. The Chinese population is now estimated at over 26 millions, or 90 per cent. of the whole. It is not surprising to find that Chinese place-names have almost entirely swamped the old Manchu names except in the north and east. Their classification according to meaning and origin is attempted here. An English transcription has been employed, apparently according to the well-known Wade system. But the value of the book would have been much enhanced by the addition of the Chinese characters. We find, for instance, that *yang* may stand for ocean, sheep, poplar,

or simply a family name; we cannot be certain of translating it correctly without the Chinese character to distinguish it. A chapter is given to non-Chinese names, Manchu, Mongol, Korean, Japanese, Russian, and even English. A longer section on Manchu would have been welcome. The number of Manchus left in Manchuria appears to be something over a million. The Mongol population is ebbing westwards even in Inner Mongolia. On the other hand a rising tide of Korean immigration is making itself felt in eastern Manchuria where the Koreans are believed already to number one million. The book ends with a bibliography of the subject. A glossary of Chinese words would have been useful, especially as it is by no means easy to arrive at their meaning in many place-names in the text.

J. H. R.

IN THE ARABIAN DESERT. By ALOIS MUSIL. Arranged for publication by KATHERINE MCGIFFERT WRIGHT. *London: Jonathan Cape* 1931. 9×6 *inches;* xiv+340 *pages; illustrations and map.* 18*s*

The record of Alois Musil's Arabian travels has up to the present remained out of reach of the general reader, being embodied in several formidable volumes in the American Geographical Society's 'Oriental Explorations and Studies' series. To remedy this, the present volume, which contains an abridged version of two of his books in the above series—'Arabia deserta' and 'Manners and Customs of the Rwala Bedouins'—has been prepared. Much of the topographical and historical material has been omitted—in favour of a general picture of a society which is rapidly being transformed under the impact of external forces. The framework of the book is Musil's two journeys through Northern Arabia in 1908–09 and 1914–15 made as the guest of Nuri ibn Shalan, the head of the Ruwalla tribe, whose influence was in the ascendency. Much of his work was done in the region round the Sirhan depression, though he made one journey across to the Euphrates. Translations of a number of Badawi poems are included. The spelling of place-names will be unfamiliar to English eyes. G. R. C.

THE STORMSWEPT ROOF OF ASIA; by Yak, Camel and Sheep Caravan in Tibet, Chinese Turkistan and over the Kara-Koram. By EMIL TRINKLER. *London: Seeley, Service & Co.* 1931. 9×6 *inches;* 312 *pages; illustrations and map.* 21*s*

The work of Dr. Emil Trinkler, whose early death has removed an enthusiastic and able student of Central Asian geography, has already been brought to the attention of the Society by two papers published in the *Journal*. The German account of his journey in 1927–28—'Im Land der Stürme'—has also been reviewed at some length in these pages (*G.J.*, vol. 75, p. 365), and it is sufficient here to commend this translation, which reads easily and is well illustrated. The map might have been more easily placed, but, since it is not unusual to find no map in books of this character, complaint is ungrateful. G. R. C.

VOICELESS INDIA. By GERTRUDE EMERSON. *London: George Allen and Unwin* 1931. 9½×6 *inches;* 458 *pages; illustrations and sketch-map.* 15*s*

It will not often happen that a lady will settle down for the better part of a year alone in a remote Indian village to study Indian life at first hand. But that is what the author of this book, an American lady, did, and she has described the results of her experience in this vividly written work. She was told that a woman living alone in such a village would not be regarded as "respectable"; but under the auspices of the Balrampur estate, to which the village belonged, she built a house, engaged servants, threw herself into the life of the village, rendered unauthorized medical aid to numerous patients who practically forced themselves upon her, and by her unaffected friendliness got into real touch with all classes of the com-

munity, and won their affectionate regard. Of course her presence was at first a puzzle to the villagers; it was thought that she must be a spy; but the local police kept a friendly eye upon her, and she had no unpleasant experiences. She soon realized that without the active support of the estate authorities her house would never have got built, for she would have been unable to command the necessary labour. But she regularized herself by consulting a pundit as to an auspicious day for beginning the work, and by holding the necessary *puja* in the presence of the local estate officials, and fifty or more uninvited guests. The same procedure was followed when the finished house was to be occupied, but on this occasion grain was distributed to a number of poor people, and a dinner was given to some forty of the local notables, which was served on large cloths spread on the ground before the house. At one of these Muhammadans were seated, Hindus of three castes at another, the Brahman postman alone at another, the Tharu headman by himself at another, and the Marwari tradesmen at another. Thus accepted, Miss Emerson began her work of making a detailed study of village life without restraint or hindrance. The village, a fairly prosperous one of some two hundred houses, was Pachperwa in northern Oudh, near the Nepal frontier and the *tarai*, and connected by metre-gauge railway with Gonda, the capital of the district, and with Gorakhpur. In clear weather a section of the Himalaya could be seen, dominated by Dhaulagiri, 26,800 feet. The sub-Himalayan region in which the village is situated is one-sixth swamp or *jhil* (expanses of shallow water), and is more or less completely under water in the rainy season. It is therefore water-logged and thoroughly malarious.

Much of what Miss Emerson says of Pachperwa would be equally true of the majority of the 750,000 villages of India. Pachperwa had its temple, mosque, police station, dispensary, its outcaste quarter to the south-west of the village, its quarters for shopkeepers and artisans, and for the Marwaris, those ubiquitous enterprising traders from Rajputana, who did all the big business. It also had its returned emigrants from Trinidad and elsewhere, who looked down upon their untravelled kinsfolk. Like most of its fellow villages it had no sanitation, no running water supply, no ice, and no conveyance for hire of any kind, not even at the railway station. It bore evidence of its neighbourhood to the *tarai* in the Tharus, a primitive Mongoloid tribe, supposed to be impervious to malaria, who were experts in thatching with the *tarai* grasses, and would only accept payment in bottles of spirit distilled from the flower of the *Mahua* tree.

The chapter headings and the index show that few aspects of Indian life escaped Miss Emerson's keen observation, and her treatment of such vital questions as caste, religion, the social customs, superstitions, and real beliefs of the villagers, climate and disease, the relations of the village to the Estate authorities, the Government, and the police, the cultivation of the land, money-lending, local industries and trade, is fresh and full.

Miss Emerson is ready with comparisons with conditions in America. She believes that Indian administration is in many departments corrupt. What can be expected when subordinate officials are given enormous responsibilities and inadequate pay? The only difference she can discover between Pachperwa and New York or Chicago is that while graft in the latter places can be estimated in millions of dollars, in the former it is in hundreds of rupees. In speaking of deaths from snake bite in India she remarks that the mortality is insignificant compared with the deaths from motor car accidents in America. Again, she shows her sympathetic understanding of Indian mentality by quoting the Indian reply given when the enormous loss to the country occasioned by the preservation of old and useless cattle was pointed out to them: "Would you shoot your mother when she became old and useless?"

Readers of this book will not fail to notice that Miss Emerson's references to the British administration of India are generally unfriendly. Not that she saw much of British officials when she was at Pachperwa; she only mentions one visit of a British officer, the District Superintendent of Police. But her feeling is perhaps not surprising when we realize how profoundly she was affected by the poverty and the consequent undernourishment of the people, which made them peculiarly unresistant to disease and lacking in recuperative power, and by their appalling ignorance of the preventable causes of disease. She naturally comments upon the small proportion of the public expenditure devoted to medical relief and public health. So, when she mentions things to the credit of British administration, she usually counters by a reference to something to its discredit. Thus she says, "One hears much of the important contribution to the agricultural prosperity of India of the Government irrigation projects, important none the less because they proved a handsomely paying investment. A little less talked of, perhaps, is the record of increasing poverty and distress over wide areas of Bengal, once known as the garden spot of India, through the unintelligent destruction here of the indigenous canal and drainage system of pre-British days." This is a controversial matter, and it is probable that most of the deterioration of Western Bengal has been due to secular causes against which no Government could contend.

The book has a useful glossary of Indian words, in which the Mochis, or shoemakers, are described as a Muhammadan occupational caste. They are generally Hindus. The illustrations are excellent. Miss Emerson has produced a valuable and well-written book, which is thoroughly interesting, and deserves careful study. W. H. A. W.

AFRICA

L'ALGÉRIE. By AUGUSTIN BERNARD. (Collection coloniale, publiée sous la direction de Henri Gourdon.) *Paris: Larousse* 1931. 9×6 *inches;* 224 *pages; illustrations and maps.* 30 *fr.*

Algeria of recent years has been visited increasingly by travellers of many nationalities. But though general books on it in English are now numerous few of these give much information of great value to the geographer. Professor Bernard has an unrivalled knowledge of the country in all its aspects, and in this member of the 'Collection Coloniale' gives a valuable account of its story, its problems and the way in which these are being attacked. It is interesting to note that on the possibility of distinguishing between the Arab and Berber elements, a question upon which much has been written, he expresses himself very definitely —"there are no Arabs in Algeria, but only Berbers more or less Arabized" (p. 36). This statement is somewhat qualified later when a distinction is made between the small bands of warriors which entered in the seventh century, and the more important invasion of the eleventh century. In the latter case the nomads brought with them their wives, children, and flocks, and overturned completely the earlier Berber economy, giving rise to new tribal groupings and modifying both the distribution of the population and the chief occupations. The first categorical statement is thus probably intended rather as a warning to those who confuse "race in the biological sense with language and civilization," than as a complete formulation of the facts; but it does serve to emphasize the great persistence of the Berber type. Another interesting point is that the Khabyles, one of the purest of the Berber elements because of their isolation among the mountains, are ceasing to play their earlier part as the great reserve of labour within Algeria. They now prefer to migrate temporarily to France, especially to Paris

and the Seine department, rather than to undertake harvesting and other seasonal occupations in the lower grounds of Algeria.

The book, which is amply and beautifully illustrated, may be strongly recommended, though the absence of an index and of lists of the numerous maps and illustrations is a great drawback. There is an appendix addressed to the tourist, and a classified bibliography. M. I. N.

SHOOTING WITH RIFLE AND CAMERA: filming "The Four Feathers." By A. J. SIGGINS. *London: Victor Gollancz* 1931. 9×6 *inches;* 368 *pages; illustrations.* 18*s*

Mr. Siggins was a member of the expedition engaged in filming "The Four Feathers," a picture of the animal life of Africa which must have been seen by hundreds of thousands. Here he tells us the way in which the film was made, the preliminary plannings, the vast labour involved, the failures of most carefully planned schemes. We get an insight into the dangers associated with such work and the many demands on human patience necessary to bring it to success. It will amaze the reader to learn of the tremendous preparations involved in the photographing of a herd of hippopotamus. The book is not designed to instruct the geographer, but the naturalist will find in it points of interest about animals, and the film producer will find it full of tips on the equipment of expeditions, the makings of camps, the details of travel, the mode of dealing with natives, and numerous other practical matters connected with his specialized art. R. W. G. H.

THE LAMBAS OF NORTHERN RHODESIA: a study of their customs and beliefs. By CLEMENT M. DOKE. *London: George G. Harrap & Co.* 1931. 9×6 *inches;* 408 *pages; illustrations and map.* 36*s*

This is an admirable text-book written by one who combines academic knowledge of anthropology with local experience. It is of special interest as being the third ethnographical study from the north-western corner of Northern Rhodesia, and enables, as the author says in his preface, "missionaries, Government officials, and others who have direct contact with the natives to understand better the people and their point of view." Dr. Doke adds, "I wish I had had more knowledge of the significance of native customs when I first went to live among the Lambas: I should have been saved from many a grievous mistake and many a misjudgement."

Dr. Doke has his limitations, and, possibly because his book was not written *in situ*, it is not unfair to describe it as a text-book. He describes and tabulates the customs of the tribe and, when he can, explains their origin. All this is excellent. The calendar of work (pp. 94–9) is very good, and being on the same lines as another book in this group makes comparison easy. Food (99–108) is dealt with more completely than elsewhere, and some details like the making of a dug-out are quite new. The chapters on religion and cognate subjects show balance as well as understanding. The book fails however to give that at which the author aimed, "the ability to see through Bantu eyes"; the power, as Mary Kingsley put it, of "thinking black." Except for the chapter on Childhood it is not a human document. Dr. Doke's Lambas do not seem to live: they are specimens. If only he had given us a picture of, say, a carrier falling with his load on the top of him while his fellows shriek with laughter, so that we could visualize their idea of humour, this book would have been on a higher plane than it admittedly is.

A few particular criticisms: At times the author differentiates between what was and what is, but at other times he refers to past customs in the present tense: *e.g.* slavery and the killing of widows at funerals. This is a mistake and liable to misrepresentation. He courageously adopts the English plural "The Lambas,"

yet when using solitary Lamba nouns in the English text he puts in the mute prefix as in *umuntu*, *umulandu* (naturally substituting an apostrophe in a sentence, as in *tukasolololo' mulandu*). Admittedly the prefix is there, but writing it seems inconsistent with "Lambas." Unless they are clerical slips it is difficult to understand the orthography of *akapoopo* (p. 132) and *cheeiso* (p. 133). The duplicated vowel is not orthodox, and does not appear to be explained in this book.

On p. 162 we read: "A Lamba girl matures early, by the time she is 13 or 14 the marriage will be consummated." It would be interesting to know if Dr. Doke has proved, from known dates of birth, that the girls do mature early. Kafulafuta Mission has been established long enough to give us ample data if records have been kept. In my experience it is only in appearance that girls mature early. They marry when they look about thirteen or fourteen, but are in reality sixteen or seventeen.

The book is well produced, and the use throughout of plate paper enables the numerous illustrations to appear in their correct place in the text. There is a bibliography, and a good glossary and index. It is however regrettable that it has not been possible to produce the work at a lower price. F. H. M.

MÉMORIAL DU SERVICE GÉOGRAPHIQUE DE L'ARMÉE. Tome V. La Carte D'Algérie, 1830–1930. *Paris: Imprimerie du Service Géographique de l'Armée* 1930. 12×9 *inches;* iv+162+104 *pages; illustrations and maps*

In this centenary volume General Bellot, the Director-General of the Service Géographique, gives us a most interesting and complete description of a hundred years of mapping. Nothing which could add to the historical value has been omitted. The map indexes, the extracts from the maps themselves, the summaries of the work of the officers concerned and their portraits, and the final lists, form a record which might well be copied by our colonial surveys.

It is curious that Algeria should be, for its development, so much better mapped than France itself. For example, Algeria has 184 published sheets at the 1/50,000 scale and France has but 94. Survey history in Algeria is similar to that of India. Carried out by soldiers, based upon a properly rigorous triangulation and following a definite programme of control measurement and topography it has been largely, if not wholly, divorced from cadastral or property surveying. It happens not infrequently in our colonial surveys that slump times result in cutting down staff to a point at which only the irreducible minimum of property surveying is done, and no control and no topography are possible, with the result that when times improve, the maps are so out of date as to be nearly valueless and the triangulation so damaged as to call for re-observation and repair. The Algerian survey has not been without its indecisions and interruptions, but it has never been allowed to lose capital value.

The first few years of work were such as the survey of India has often enough carried out on the frontier. A few astronomical points, a hasty triangulation, and many routes. The intrigues campaigns and revolts of Abd-el-Kader made regular surveying too precarious. The first maps at 1/400,000 and 1/1,000,000 were substantially better however than the "Boer or Briton" map which had to suffice most of us in the early days of the Boer War. In 1853 a new and general triangulation was begun. It was designed as a grid of two parallel and three meridional chains, and it is interesting to note that by then the terminals of the original reconnaissance bases and the centres of the old stations had mainly disappeared. It is in connection with this triangulation that one finds the earliest mention of Perrier, who was first to suggest and later to direct the connection between Spain and Algeria, and so to prolong the Anglo-Franco Spanish meridional arc. At this time the Italians connected Sicily to Tunis.

It was not till 1869 that it was decided to introduce a general topographical map at 1/80,000. The application of this scale to Algeria seems curious. It had no special justification in France except that it was just possible financially and the 1/50,000 was not. It seems more curious still to prolong the Bonne projection from its French datum so far to the south. Fortunately both decisions were overruled subsequently. The field work was, from the first, at the 1/40,000 scale and was good enough for the 1/50,000. A thoroughly good map in six colours is the result. Towns and buildings in red are unfamiliar to the English eye and the contours are too lightly printed to retain character in the hill shading. One misses the black which is practically confined to names and railways, although it is the neatest and best mapping colour, but ground forms are really well shown and Algeria may well feel proud of such a map. There are a whole row of other scales larger and smaller. The 1/10,000 and 1/20,000, the 1/200,000 and 1/500,000 of French practice are all good maps, and particularly the last mentioned. This is a scale which would be useful in Uganda or Nyasaland. There are also 1/M, 1/2M, and an admirable 1/5M. No doubt to-day it is past praying for, but a good map on this last scale from Rejaf to Cape Town would indeed be a best seller. All these maps are illustrated by well-chosen extracts.

Not the least pleasant feature of the report is its close personal and human interest. To any British map-maker such names as Perrier, Bourgeois, and Bellot must engage a lively attention. We congratulate General Bellot very heartily on his report and Algeria on the possession of a record of the greatest value. Fortunately the idea is not patented and it may be hoped that our colonial surveys may follow this example (as Kenya has done in humbler way) and record the facts and personalities which are already nearly forgotten. H. S. L. W.

NORTH AMERICA

CANADA'S WESTERN ARCTIC: Report on Investigations in 1925–26, 1928–29 and 1930. By L. T. BURWASH. *Ottawa: F. A. Acland* 1931. 10×7 *inches;* 116 *pages; illustrations and maps*

Whether from choice or necessity civilization has been gradually extending northwards and Canada has been second to none in developing the resources of her Arctic Coast. With this object in mind Mr. O. S. Finnie, Director of the North-West Territories and Yukon branch of the Department of the Interior, directed Major Burwash to make comprehensive observations of the economic possibilities of the country and the condition of its Eskimo population. In this paper-bound volume Major Burwash describes and gives the results of his three expeditions to the coast between the Mackenzie River and the Boothia Peninsula. It is written in the severe style which seems inevitable in an official report, but with a very little imagination one can picture the difficulties which he encountered and appreciate his resource in overcoming them. As it is, it is a useful book of reference which would be improved by the addition of an index.

Often in summer and always in winter the author travelled and lived with the Eskimos, the only way to form a fair judgment of their conditions of life. He seems to agree with the view of many other Arctic travellers that the Eskimo is a better man, mentally and physically, before his mode of life has been influenced by the white trader and the amenities of civilization. Major Burwash also did a lot of work in searching for relics of the Franklin Expedition. He questioned the natives and found such things as rope, wood, and broadcloth, but no written record. He decided that though it is possible that a record is hidden somewhere on King William Island a search party would be extremely lucky if they found it. Copper exists in several places, but Major Burwash thinks that the advantage

obtained by the presence of fast-flowing rivers is offset by the absence of fuel, lumber, and an ensured water supply sufficient for a large community.

The illustrations are numerous, but so small that they are often hard to make out, and fewer and larger pictures might have been more useful. There is an appendix which contains some brief but generally sound advice concerning methods of Arctic coast travel in summer and winter. It ends with a list of "Don'ts"—the last of which is "Don't go to the Arctic without a definite objective." It is the only suggestion of sentiment expressed in the book.

J. M. S.

CENTRAL AND SOUTH AMERICA

A NATURALIST IN BRAZIL: the Flora and Fauna and the People of Brazil. By KONRAD GUENTHER. Translated by BERNARD MIALL. *London: George Allen and Unwin* 1931. 9×6 *inches;* 400 *pages; illustrations.* 25*s*

The author is a biologist and close observer of nature. He takes us into the heart of the rain-forest and gives us a series of excellent sketches on its teeming wealth of vegetable life. We are told of the great trees with their enormous buttresses, the stilted roots, the characteristics of the branches, the forms of the crowns, leaves, and flowers. We have excellent descriptions of the tangle of cables, how they throttle the tree-trunks, spread like rigging through the branches, or wind like serpents over the leaf-strewn soil. Then the author takes us into what he calls the desert, not indeed a grey waste of sand, but vast stretches of grassy Brazilian plain where the vegetation is sparse and impoverished compared with the forest from which we have emerged. There are many interesting observations on animal life. The author gives his views on how the continent has been populated and the order in which the different groups of animals arrived on it. But here we enter regions of doubt and speculation, and it is probable that some of the opinions of the author would not receive general acceptance. Sound and colour can never escape notice in any discussion of tropical biology. Hence we find descriptions of the booming of the birds, the whistlings and gruntings of amorous frogs, and the grinding notes emitted by the cicadas. Also we have some interesting views on the gorgeous displays of plumage in the equatorial zone. The book is thus full of varied information and deserves study and reflection from those who are interested in tropical biology. R. W. G. H.

LÄNDERKUNDE SÜDAMERIKAS. By OSCAR SCHMIEDER. (Enzyklopädie der Erdkunde. Edited by OSKAR KENDE.) *Leipzig: Franz Deuticke* 1932. 10×7 *inches;* 252 *pages; illustrations and maps. M.*20

This is a systematic account of the geography of South America on regional principles. The author has taken opportunities afforded during his tenure of professorships at Cordoba in Argentina and Berkeley in California to become acquainted with the literature relating to South America and with the continent itself at first hand by extensive travels. To judge by the ripe knowledge shown in the text he has made good use of the selected list of five hundred works and papers mentioned in the bibliography he appends to his book.

After a preliminary chapter on the discovery, the build, and the peoples of South America, Professor Schmieder passes on to a detailed account of the twenty-one regions he recognizes, under the ordinary heads of relief and structure, climate, vegetation, and human settlement. In the treatment of each of these regions a considerably greater share of attention is given to historical geography than is common with most English writers, and the native peoples past and present, in whom Professor Schmieder appears to be specially interested,

are carefully described. On the whole the regions of Spanish culture seem to be more graphically portrayed than those of Brazil. In dealing with the former Professor Schmieder is on ground he knows well, and his style is admirably lucid. The whole book may be fittingly called an essay in human geography, based on regional principles, in which the illustrative matter is of quite secondary importance compared with the text. A perusal of this book shows well how many gaps there are in our knowledge of the details of South American geography, and though Professor Schmieder probably would not claim to have added much original material to this knowledge, he has at least assembled in a compact and readable form the results of the best work done by others. E. W. S.

AUSTRALASIA AND PACIFIC

GROWING UP IN NEW GUINEA: a Comparative Study of Primitive Education. By MARGARET MEAD. *London: George Routledge & Sons* 1931. 9×6 *inches;* xii+286 *pages; illustrations and sketch-maps.* 12*s* 6*d*

Full-length studies of primitive education have been very few, and one of these was Dr. Margaret Mead's 'Coming of Age in Samoa.' Her present work is the record of similar investigations made amongst the Manus of the Admiralty Islands, north of New Guinea. A group of eighty-seven children, under or just at the age of puberty, was taken for inquiry, each child being studied in detail, and his heredity, family background, relationship to playmates, physical defects, and character traits carefully noted. Parallel with these investigations ran a study of the social structure of the village, carried out by Dr. Mead's husband, Mr. Reo Fortune, and then the members of the whole group were observed in relation to one another and to their parents. Their play and conversation was analysed; experimental situations were produced and the responses recorded. The investigation was conducted on the assumption that a child is so subject to environment that the only way to arrive at any conception of original nature is to study it as modified by varying outside conditions. The Manus offer a homogeneous and simple background for the study of the individual, since their social life is still almost entirely untouched by outside influences; no missionaries work amongst them, and they live their own lives without economic dependence upon white culture. Dr. Mead earns the confidence of the reader immediately she states that her investigations were made in the Manus language; her somewhat popular title need not deter the anthropologist, since enough has been said to show that her methods were scientific, and she herself is Assistant Curator of Ethnology at the American Museum of National History; while the ordinary reader will thank her for having avoided, so far as possible, the use of technical jargon, and will read with profit and interest this picture of human education in miniature.

O. R.

THE PSYCHOLOGY OF A PRIMITIVE PEOPLE: a study of the Australian Aborigine. By STANLEY D. PORTEUS. *London: Edward Arnold & Co.* 1931. 8½×5½ *inches;* xvi+438 *pages; illustrations and sketch-maps.* 30*s*

This volume will be a disappointment to many, for its title raises hopes not borne out on perusal. The book consists of two parts: the second, and by far the more important, contains the account, with considerable comparative matter, of the psychological tests to which Professor Porteus submitted his subjects. These experiments were necessarily limited; probably the most satisfactory and important were those in which the subject follows with a pencil or pointed stick a succession of maze patterns of increasing complexity. It has been shown that so

far as whites are concerned success in this test correlates with socially valuable qualities, including capacity for industrial training, whilst there is also a high correlation with the Binet intelligence test. "Hence," to quote Professor Porteus, "our results with the aborigines may, to a certain degree, be considered indicative of level of intelligence, although their main value is as a measure of planning capacity and prudence." Whether this is a fair deduction or not, it is interesting to note that the average score of sixty-five adult natives of the Kimberley and Beagle Bay districts gave a result equivalent to that of European children of ten and a half years, while a smaller group of Central Australian natives gave an equivalent of twelve years.

The first part of the book is devoted to an account of the author's wanderings, which took him to the North-West coast and the central area of the continent, and constitutes a pleasantly written and well illustrated record. C. G. S.

POLAR REGIONS

COLD. By LAURENCE MCKINLEY GOULD. *New York: Brewer, Warren & Putnam* 1931. 9×6 *inches;* x+276 *pages; illustrations and maps*

This book is a personal description of a sledge journey during the Byrd Antarctic Expedition from the base on the Bay of Whales to the Queen Maud Mountains. Dr. Gould in his foreword says that the journey has been called the "last real polar sledge journey," but he does not tell us why it was so described.

The success of a travel book, unlike that of a novel, cannot be judged by the number of copies sold; but rather by the use it would be to a traveller who found himself under similar conditions to those described by the Author. This book is written for the general public and does not pretend to deal with the scientific work of the expedition. But even so it would be none the less interesting to read if it contained a little more solid matter. One would like to read more about their sledging technique—the distances covered under various conditions and the methods of navigation and mapping which they employed. For instance, the map of the Queen Maud Mountains which is given suggests that fairly extensive charting was done, but a calculation from the dates of the journey and what they computed to be their total distances gives a travelling average of 20 miles per day. This would be surprisingly fast sledging even if no surveying were done, and one would like to know more of the details. A geologist, too, might have given us a somewhat more comprehensive description of the Rockefeller and Queen Maud Mountains.

Dr. Gould had meant to do most of his geological work with the help of air transport. He had hoped to fly to the Queen Maud Mountains. But after the loss of the Fokker in the Rockefeller Mountains Admiral Byrd did not like to risk either the Ford or the Fairchild before the polar flight; so the geological party had to rely on transport by dog sledge.

The party consisted of six men and five teams of nine dogs each. When the supporting party left them they calculated that they would have to pull nearly 1100 lb. per sledge, which, as Dr. Gould says, is a "staggering load." He did not see how these loads could be reduced, but it appears that the journey was handicapped by the fact that it was so very up to date. The scientific results, for instance, would have been no less great had the 65 lb. of motion picture equipment been left behind and the 300 lb. wireless transmitting outfit exchanged for a 30-lb. time-signal receiving set.

The account of the journey itself is thoroughly interesting, but one gets a little tired of the preparations. In this respect the party do not seem to have made

much use of their excellent Polar library. There are pages describing how, by trial and error, they evolved and manufactured the best types of sleeping bags, cookers, sledges, clothing, and tents. Very little seems to have been prepared before they left America, and consequently most of the forty-two members of the expedition had to lend a hand in getting the party ready to start. However in spite of everything they accomplished their journey with complete success. A number of new peaks and glaciers were seen and named, and it was proved that Amundsen was wrong about either the position or the existence of Carmen Land. It was an excellent journey, but one feels that its potential value was enormously decreased because it was allowed to become a safety factor for the polar flight. This meant that the party had to leave their depots on a course due south from the Bay of Whales to the Queen Maud Mountains. Their course across the Ross Shelf Ice was almost identical with Amundsen's, whereas had it lain 250 miles farther east the problems which concern the eastern boundary of the Ross Sea would probably have been solved. As it was they compute that with all side trips they travelled about 1500 miles to map a 200-mile stretch of mountains: a remarkable achievement, but one is inclined to feel that so much energy might have been better expended. J. M. S.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

THE SURFACE-HISTORY OF THE EARTH. By JOHN JOLY. Second Edition. *Oxford: Clarendon Press* 1930. 9×6 *inches; 212 pages; illustrations and maps.* 8*s* 6*d*

This second edition of Professor Joly's well-known book has been somewhat enlarged by the inclusion of some new information on radioactivity of materials. The author's general theory may be briefly summarized as follows: The continents composed of granite or allied rocks together with a relatively thin layer of sediments are underlain by a denser material such as basalt, and in accordance with the principle of Isostasy, which is assumed to prevail, the lighter continental masses are supported by the denser substratum. The continental layer contains various radioactive materials, the changes in which result in the production of heat throughout the layer. The substratum is also radioactive, but less so than the continental layer. The latter is considered to extend to a depth of some 20–40 kms., and its thickness is such that in general the amount of radioactive heat generated in a given time is sensibly equal to the heat which escapes at the surface by conduction from below.

Under these conditions the radioactive heat generated in the basaltic substratum, being unable, as the author supposes, to escape upwards through the continental layer, accumulates and causes the temperature of the basaltic layer to rise until fusion takes place. The lowering of density and expansion of volume caused by fusion of the basalt result in diminished support for the overlying continental layer. The continents therefore sink, and the outer crust is subjected to tension resulting in fissures through which some of the basalt may find its way to the surface, causing extensive "basalt floods" such as the Deccan traps, Antrim basalts, and others. When the basalt melts, tidal forces act upon it which tend to tow the continents over the liquid substratum, so that ultimately the continental layer is towed off the area under which the melted basalt occurs. Therefore the part of the basalt which was previously covered by a continental layer now passes under the ocean, and heat can escape from it. This results in consolidation of the previously melted basalt with attendant shrinkage and compression, which gives rise to folding of the crust. The continental area is also said to rise at this stage,

but as the continent has been towed off to another region, presumably it is the ocean floor that will rise.

The mechanism is ingenious, though somewhat crude. It has some serious drawbacks. Its behaviour does not agree with geological facts, and it is almost certain that it will not work. The great basalt floods have attended the rise of continental areas, and not the periods of marine transgression. The periodicity which the author sets out to account for is not so simple as was formerly believed, and the number of "revolutions" tends to increase with expanding knowledge of various parts of the Earth's surface, and the revolutions of one continent are out of step with those in other continents. It is not explained how the melted basalt under the oceanic area on to which the continental layer is towed allows the basalt to cool under those conditions so as to make the continent rise.

Further, it has been shown from the known properties of the Earth's crust that tidal forces are incompetent to tow the continental layer over the substratum. Without this towing the process cannot be periodic in any sense. The author assumes, also, that basalt melts at a lower temperature than granite, while in reality, given sufficient time, granite melts at a much lower temperature. Dr. Harold Jeffreys has shown by rigid analysis (as opposed to the somewhat crude arithmetic of the author) that no amount of radioactive heat generated inside the crust can ever make the process periodic, but can only affect the temperature gradient.

This edition is illustrated, like the former, by some excellent views of the Alps and the Grand Canyon (with some misprints). They increase the interest of the book to the general reader, but have no obvious connection with the text. O. T. J.

PHYSICS OF THE EARTH—II. THE FIGURE OF THE EARTH. (Bulletin of the National Research Council, Number 78.) *Washington: National Academy of Sciences* 1931. 10×7 *inches;* vi+286 *pages; illustrations and diagrams*

This volume, numbered the second of a series which will make nine or ten, has, says the title page, been prepared under the auspices of the National Research Council Committee on Physics of the Earth by the members of four sub-committees of the subsidiary Committee on the Figure of the Earth, with the co-operation of the Division of Physical Sciences, the Division of Geology and Geography, and the American Geophysical Union. Under these formidable auspices the work has unfortunately got much out of scale. Six chapters are devoted to Tides in the Ocean and Earth; nine to Gravity, Deflection of the Vertical, and Isostasy; and one to Variation of Latitude. The essential subject of the title, the Figure of the Earth, does not appear to be included in these three subdivisions, but is actually dealt with in Chapter IX entitled "The Shape and Size of the Earth," by Mr. W. D. Lambert of the U.S. Coast and Geodetic Survey. His treatment exhibits the general fault of the book, that it is good in the more recondite mathematical parts, and bad in the simple and practical parts. After a long historical introduction which brings in Dante and Columbus he passes rather rapidly over the nineteenth century, omitting Puissant and Everest, and saying no more of Clarke's figure of 1866 than that it was "derived by the method of least squares," and widely used in geodetic work. That it was adopted for and remains the figure used for the whole of North America is not mentioned. "The only ellipsoid since Clarke's time based on deflections both in the meridian and in the prime vertical that has found any general acceptance is Hayford's . . . the spheroid that best fits these corrected deflections in the United States probably approximates closely to the spheroid that best fits the earth as a whole. With this idea in mind the Section of Geodesy of the International Geodetic and Geophysical Union

in 1924 adopted the Hayford ellipsoid of 1909 as the basis of the International Ellipsoid of Reference."

Let us once more formally deny this pretence of general acceptance at Madrid. At that meeting it was demonstrated that no geodetic operations in the restricted latitudes of the United States could discriminate between corrections to the radius and the flattening. At that meeting it was also demonstrated that Clarke's figure of 1880 fitted the European arcs of meridian better than Hayford's. The demonstrator, it is true, could not obtain support for Clarke 1880 as an international figure; but there was strong objection to Hayford's, which when put to the vote was carried only by 19 votes to 17, with 12 not voting. So much for the fiction of general acceptance. The quantity most in dispute was the flattening, which Hayford made 1/297. There has since been ample evidence from gravity survey that the flattening in Europe is about 1/293 or 1/294, and in the western United States not more than 1/300. Whether these figures indicate that the equator is elliptical or only that the effective flattening is different over wide regions of the Earth is a major problem of modern geodesy, which Mr. Lambert does not so much as mention. In other simple but fundamental questions Mr. Lambert's treatment is unpractical. He scarcely mentions the principles of modern geodetic triangulation: the replacement of difficult meridian arcs by circuits, the influence of easy and rapid base measurement, or of accurate wireless longitudes. His account of Laplace Points says that deviations in the prime vertical may be obtained from comparison of geodetic and astronomical azimuths or directly from a comparison of the longitudes, whereas in fact, as he himself has remarked just before, the deviation is deduced from the longitudes and used to correct the astronomical azimuths and thus control the geodetic. He says little of triangulation adjustment, nothing of the standard of accuracy, nothing of recent methods of adjustment on the projection instead of on the spheroid, nothing of recent geodetic tables. Nor can we say that these important matters are treated properly elsewhere in the book. Some of them appear in Chapter XII, "Geodetic Instruments," by Mr. D. L. Parkhurst, or in Chapter XV, "The Determination of Geographic Position," by the late Mr. C. V. Hodgson; but there we have nothing of modern theodolites, nor of the prismatic astrolabe, nor of modern base apparatus with straining trestles and divided scale on the invar tape. Triangulation is classed not by the triangular error but by the average error of adjusted sides, and we have the astonishing understatement that the error of a difference of longitude by radio signals is little if any greater than the error in a determination by wire telegraph.

Chapter VII, on Isostasy, is naturally written by Dr. William Bowie, and in view of recent discussions it is important to examine carefully his latest pronouncement on a question on which he has written so much. We read: "The outer portion of the earth is generally called the crust. It has been found by geodetic investigations to extend to a depth of approximately 60 miles below sea-level. . . . According to the principle of isostasy, if the earth's crust were cut into prisms of the same cross section by imaginary vertical planes the prisms would have the same mass if the isostatic condition were perfect. This means that the pressure exerted by these prisms on the subcrustal material at the depth of 60 miles below sea-level would be uniform throughout."

Now 60 miles is the 96 kilometres which Dr. Bowie found for the "depth of compensation" from deviations of the vertical and gravity anomalies within the United States. By what most people would call a grave misuse of the method of least squares Hayford found 122·2 km., and Bowie modified this to 96 km. There is little numerical justification for saying that under the United States the depth of compensation is 60 miles rather than 40 or 80, and still less for giving a world-

wide extension to this figure. (See Dr. De Graaff Hunter in the recent discussion published in the *Journal*, 78, 454, Nov. 1931, or his paper at the Geophysical Meeting of the R.A.S. and discussion thereon, *The Observatory*, December 1931.) There is no justification except convenience in calculation for continuing to prefer Hayford's hypothesis to Airy's. There is no "General acceptance of isostasy" of the pattern visualized by the United States Coast and Geodetic Survey, and continual assertion to the contrary does not alter the fact. This chapter is the least satisfactory in the book.

On the other hand there are valuable chapters on many recondite matters, mostly from the pen of Mr. W. D. Lambert. His discussion of Earth Tides, of Tidal Friction, of the Variation of Latitude, and of the Dynamical Figure of the Earth (in Chapter IX) are full of good stuff, and valuable as a guide to the student of these difficult and intricate subjects, most interesting to the geographer. The secondary effect of the ocean tides in deforming the Earth by their varying load on the coast is felt far inland and is often greater than the true earth-tide. The energy dissipated by tidal friction in the ocean is of the order of 4,000,000,000 horse-power, and the loss is almost entirely in shallow seas, Bering Sea contributing about two-thirds of the whole, and the seas about our own coasts one-tenth. The flattening of the Earth determined from the theory of the moon agrees with Clarke 1880 and not with the International spheroid. Seasonal variation of barometric pressure rather than the irregular distribution of snowfall seem responsible for the annual term in the variation of astronomical latitude. For a careful and authoritative discussion of these topics we are grateful to Mr. Lambert; and to Dr. Doodson of the Liverpool Tidal Institute for his careful exposition of Tidal Theory in Chapter II. Geographical text-books continue to repeat what tidal specialists have disproved and abandoned: such as the wave-theory which is now "dying a natural death after having held tidal theory in bondage for many years." The tides in the Atlantic are now held to be generated in that ocean and magnified by resonance, without much propagation of a tidal wave from the Southern Ocean.

To sum up: this book contains excellent geophysics, but its geodesy, especially on the practical side, is poor; the former culled from the world at large, the latter rather too narrowly restricted to the ideas and the practice of the U.S.C.G.S., and hardly doing justice to that. A. R. H.

EMIGRATION, MIGRATION AND NOMADISM. By the late WALTER HEAPE. Edited with a preface by F. H. A. MARSHALL. *Cambridge: W. Heffer & Sons* 1931. $9 \times 5\frac{1}{2}$ *inches;* xii + 370 *pages; portrait.* 12*s* 6*d*

This is a valuable and interesting contribution to our knowledge of the voluntary movements of animals and their relation to geographical environment. The author discusses the subject of territory and proves by a large assemblage of facts that the instinct to secure and hold a territory is a factor of importance which has not yet received anything like the study it deserves. He considers, and indeed clearly demonstrates, that so important an attribute of human civilization was not evolved or invented by man, but is a widespread and deep-seated instinct in the life history of numerous animals. Then he discusses animal emigration which differs from the better-known instinct of migration in that the animals, when they abandon their home territory, show no disposition ever to return. He gives several examples of these emigrant species and enters into a valuable discussion on the driving forces that originate their movements. On the difficult problems of dispersal and migration there is a wealth of information and stimulating discussion, but space will not permit us to enlarge on the author's views. But we can say with confidence that he has prepared a work which should arouse interest

and suggest research. One of his chief objects, he states, has been to stimulate investigation into the comparative physiology of the reproductive system, which plays a part in the history of evolution more important than has yet been recognized. R. W. G. H.

CARTOGRAPHY

LAND FORMS AND LIFE: Short Studies on Topographical Maps. By C. C. CARTER. *London: Christophers* 1931. 8×5 *inches;* xxvi+268 *pages; illustrations and sketch-maps.* 6*s* 6*d*

Mr. Carter has rendered a very useful service in writing this book. It is intended for school use. As stated in the preface, comparatively few people can study regions at first hand: the best substitute is to study them through the medium of good topographical maps. This is not always possible for schoolboys on account of the cost of maps. But even if the maps are not forthcoming, the methods of study indicated in the book are stimulating, and the young student should gain much by reading it carefully and taking account of its excellent photographs and diagrams.

Most of the regions described are in the British Isles: a few, *e.g.* Zara, Vesuvius, and the Rhone delta, are taken from other countries. All are analysed physiographically, and an account is also given of the human activities carried on in such regions. These two studies are accomplished mainly through the medium of maps, though the author's personal acquaintance with several of the regions brings in the personal touch. The whole scheme is successful: the descriptions are interesting and commendably brief, though brevity is not sacrificed to slipshod treatment. As far as the present reviewer can judge, the book fills an important gap in elementary geographical literature.

A few details call for some criticism, though they do not mar the value of the book. The account of the Rhone delta would be enhanced if reference were made to R. D. Oldham's recent work, and if stress were laid on recent oscillations of sea-level—a question too often evaded in text-books. Some descriptions are, perhaps, rather too simplified, *e.g.* the geological structure of the Lake District, the classification of Coast Forms (Section 30), and the account of Orford Ness. Although a chart marks the mouth of Orford Haven as opposite to Orford in Henry VIII's time, it has been argued that the chart better represents the coast as it may have been at an earlier period. It is also highly questionable if "the rolled, oval, slaty shingle (of the Westward Ho! pebble ridge) is driven by *currents* from the cliffs on the south."

Details such as these are easily altered, and we hope Mr. Carter will soon be able to consider their incorporation in a second edition. J. A. S.

TACHEOMETRIC TABLES. By F. A. REDMOND. *London: Crosby Lockwood & Son* 1931. 8½×5½ *inches;* xx+256 *pages; diagrams.* 8*s* 6*d*

These new tables, of which there are altogether four, are for use with any ordinary tacheometer or theodolite fitted with stadia marks. Table I is the principal table, and occupies 240 pages of the book, out of a total of 256 pages. This gives for every foot of the generating distances G from 50 to 850 feet, the corresponding horizontal distances D, and the differences of height H for vertical angles V at intervals of 20′ from 0° to 20°. Table II is an extension of Table I to 29° 40′, and like that gives the horizontal distances and differences of height corresponding with every 20′ change in the vertical angle; but it is a short table, since the distances G are only given for every 100 feet from 100 to 900 feet. The horizontal distances and differences of height corresponding with intermediate

measures of G can be readily obtained by moving the decimal points and adding the parts. Table III is similar in form to Table II, but gives horizontal distances and differences of height for vertical angles of every 10′, 30′, and 50′ from 10′ to 29° 50′, instead of for every 20′ as in the other tables.

Unless a tacheometer with an anallatic or modern central focusing telescope is used there is always a constant, here called *k*, to be added to the measured distance, which is equal to the focal length of the object glass plus the distance from the object glass to the centre of the instrument; and on slopes this has to be multiplied by the cosine of the vertical angle for the horizontal distance and by the sine for the difference of height. In Table IV this multiplication is performed, and the correction can be taken out at a glance for various lengths of *k* and vertical angles up to 30°. This table is rather apt to confuse at first since feet and minutes of arc are both indicated by the sign ′, and inches are shown by ″.

The Introduction to the tables contains a concise account of the tacheometer, illustrated by clear diagrams, and an explanation of the formulae upon which the tables are based, together with examples of their use; while in the Preface are described the different methods of tacheometric surveying, and the advantages and disadvantages of each. The tables are especially suitable for the "fixed angle" method, which has lately gained favour. E. A. R.

ECONOMIC AND HISTORICAL GEOGRAPHY

NARRATIVES FROM PURCHAS HIS PILGRIMES. Edited by H. G. RAWLINSON. *Cambridge: University Press* 1931. 8×6 *inches;* xv+215 *pages; illustrations.* 5*s*

In the belief that Purchas's 'Pilgrims' is much less widely known, at least in schools, than Hakluyt's 'Voyages,' Mr. Rawlinson has edited this selection from the former. The extracts have not been chosen from a strictly geographical point of view, but for their adventurous quality. The defeat of the Spanish Armada and the last fight of the *Revenge*, being well known, might have given place to other incidents. The various narratives are spiritedly written, and convey a vivid, but not always a flattering, impression of the characteristics of the common Elizabethan seaman, who needed a leader of no less a stature than a Captain John Smith. The picture of the latter reading a "Cosmographicall lecture" to a horde of excited savages is proof of his mettle. Other extracts recount Hudson's last voyage, Cavendish's second attempt to circumnavigate the world, and Sir Thomas Roe's visit to the Court of Jahangir. Surely the emendation of "Usance de Lamair" to "Usance de la guerre" is a slip for "Usance de la mer." G. R. C.

VIAGGIO DEL BEATO ODORICO DA PORDENONE. Edited by GIORGIO PULLÈ. (Viaggi e Scoperte. No. 17.) *Milano:* "*Alpes*" 1931. 9×7 *inches;* 256 *pages; illustrations and maps.* L.14.50

When Yule was preparing an English version of Friar Odoric's narrative for inclusion in the first edition of 'Cathay and the Way thither' (1866) he referred to 39 manuscripts (some of which are now untraceable); while Dominichelli (1881) listed 59, Cordier (1891) 73, and van Wyngaert (1929) 93. In the present Italian version of the travels, which forms the seventeenth volume of the series "Viaggi e Scoperte di Navigatori ed Esploratori Italiani," Signor Pullè has selected the text published in 'Sinica Franciscana,' by Fr. A. van den Wyngaert, that is, Codex No. 343 (20) of the Biblioteca Comunale in Assisi, containing the version of Guglielmo da Solagna. The division into chapters and paragraphs adopted by van Wyngaert has also been followed. Though the spelling of proper names is generally different, the matter of the narrative does not vary to any very

essential extent from that given by Yule. The introduction runs to sixty-three pages, and the notes are numerous, but they throw little fresh light on the life history or travels of Odoric. Most of the matter in the notes will be found in the second edition of Yule's 'Cathay,' or in Cordier's edition of Odoric's travels. In the text (p. 198) we find Tocara as the name of the city of the pygmies, but in the footnote we are given no explanation of this name. There we have a reference to "Catham," which seems to be a typographical error for the "Cathan" of Yule's text, as the note (taken from Cordier's note in the second edition of 'Cathay') shows. Again, in the footnote on p. 208 referring to the Great Khan's palace at Taido, Yule's note has been utilized; but Yule never wrote that Amarapura was in India. The difficulties in regard to Conio (Yule's Comerum), Hus (Yule's Huz), the islands of Nicuvera and Dondin, Paten or Malamasini (Yule's Panten or Thalamasyn) and Tibet and its chief city remain as they were.

C. E. A. W. O.

HISTOIRE GÉNÉRALE DE LA NAVIGATION DU XV^e^ AU XX^e^ SIÈCLE. By F. MARGUET. *Paris: Société d'Editions Géographiques . . .* 1931. 10×7 *inches;* 306 *pages; illustrations.* 8*s*

The title of this work is doubly misleading to a layman, for it is a history of "navigation" only in the specialized sense of "nautical astronomy," while as regards the period covered, a single perfunctory chapter is devoted to the nineteenth century (up to 1882 only), and the twentieth is dismissed in a paragraph. The fifteenth century also is barely touched, and while the following two hundred years receive rather fuller treatment, it is only in respect to the eighteenth century that the history is authoritative and well documented. This monograph is, in fact, the author's important 'Histoire de la Longitude à la Mer aux XVIII^e^ siècle en France' rewritten and expanded under a new title. Captain Marguet's studies of longitude naturally led him to a consideration of allied problems, and hence, as he says in his Preface, he felt compelled to write "the history of dead reckoning and the *carta marina*." Such a history however could only be written after an exhaustive study of original sources, and a full appreciation of the cosmographical concepts of the early pilots and map-makers, an equipment to which Captain Marguet could hardly lay claim. He does not, indeed, even mention the names of men of his own nationality who made contributions to the subject, such men, for example, as Fernelius, Orontius Finaeus, Jacques Besson, and the Dieppe pilot-cartographers; nor does he consider such fundamental problems as the erroneous ideas concerning the diameter of the Earth and the equivalence of the different measures of length, which vitiated calculations of longitude made from dead reckoning. He does however bring much useful material together, and this selective and summary treatment of the history of the period that preceded the invention of instruments of precision will no doubt be appreciated by the nautical reader for whom primarily the book was written.

E. G. R. T.

HISTORY OF PALESTINE. By ANGELO S. RAPPOPORT. *London: George Allen and Unwin, Ltd.* 1931. 368 *pages; one illustration and a small map of "Modern Palestine."* 12*s* 6*d*

This is a clear and scientific account of some four thousand years of History in Palestine. It is not easy to compress so long a history into one small volume and yet make a readable book, such as this is. It should be useful as an educational text-book for many who know nothing of the Holy Land outside the pages of the Bible. Here we have described the position of this small land in relation to the great Empires of the Ancient East. It is divided into three parts: I. Pre-Israelite

Palestine; II. Palestine the Promised Land of the Hebrews; and III. Palestine the Holy Land of Christendom.

The writer clearly takes a predominant interest in Jewish History and Religion. He betrays strong sympathy with Zionism, but, unlike many of the most ardent supporters of that cause who view it chiefly as a national revival, he sympathizes with the movement as rightly a religious one. "It is our deliberate opinion that a national revival of the Jews in their ancestral home *without* the basis of religion has no *raison d'être*." "Zionism stripped of religion, the Zionism of an atheist, is an anomaly, a contradiction, an incomprehensible absurdity." Of the future outcome the author dares not prophesy—to do so "would be only mere conjecture." E. W. G. M.

GENERAL

SAILING THE WORLD'S EDGE: Sea Stories from Old Sydney. By THOMAS DUNBABIN. *London: Jonathan Cape* 1931. 8×5½ *inches;* 340 *pages; illustrations.* 12*s* 6*d*

Mr. Dunbabin has raked together nearly thirty stories of adventure, involving lawless skippers from Boston, Russian explorers of the Antarctic, sea-elephant hunters on Macquarie Island, and a whole crew of semi-piratical traders who infested the New Zealand coasts and roused the Maori tribes to massacre and civil war. It is an amusing hotch-potch, and will give many a South Sea novelist plots for his stories. A. J.

BY CARGO BOAT AND MOUNTAIN. By MARIE BEUZEVILLE BYLES. *London: Seeley, Service & Co.* 1931. 9×5½ *inches;* 316 *pages; illustrations.* 21*s*

Miss Byles represents a rare type of Australian; she has a passion for mountain climbing at, apparently, any hour of the day or night; she dislikes passenger steamers and mixed company. If you should wish to avoid her company, all you need do is to put up a sign "Frequented by English tourists." That, it must be said at once, would be a great mistake. Miss Byles is extremely good company, and her book is delightful reading. She adds little to our geographical knowledge; she climbed only one virgin peak, and that more or less by mistake; but she adds greatly to our enjoyment and understanding of the country folk among whom in all her travels she loved to ensconce herself. If a guide would not accompany her, Miss Byles, magnificently independent, was quite ready to tackle the ridges alone, fogs and storms notwithstanding; but one would really like to hear what the guides said about her afterwards, whom she dragged unwillingly into climbs they considered too risky. Her own attitude was simple enough: "We hurried up the Linda as quickly as possible, though I never understood the reason why. The prospect of possible death is before you in any case. It is only a question of whether you will have it for two hours and add to it the discomfort of breathless panting, or for three hours and enjoy them to the full." Not being guides, the readers of this book should enjoy it thoroughly. But it is a pity that the author appears in the illustrations so frequently; her recurrence creates the quite unjust suspicion that she carried a press photographer about with her, even to fairy dells on the Milford Track—which, her publishers should be informed, is not in Australia. A. J.

THE MONTHLY RECORD

BANKS AND CHANNELS OF THE THAMES ESTUARY

Following up his previous studies of the coastal waters of south-east England, and the changes to which their banks and channels have been subject from the sixteenth century onwards, Dr. H. Muir Evans treats in the January number of the *Mariner's Mirror* of the southern part of the Thames Estuary from the North Foreland to the Nore, illustrating the subject, as before, by outline charts copied from documents of various dates from 1588 on. The details can only be grasped by a close study and comparison of those charts, but a few salient facts may be here mentioned. As is natural, both banks and channels run generally in lines parallel to the general direction of the estuary, one of the most important lines of banks being that known as the Long Sand, which with certain associated banks and the channels to the south form the chief subject of the present article. As elsewhere we are confronted with various quaint names, the origin and meaning of which Dr. Evans endeavours to elucidate. The Nore, he thinks, is not, as has been suggested, the Norse word for a bay with a narrow entrance, for the older spelling was Nower or Noure, a term still applied to park land near Dorking. The Girdler, an important group of banks continuing the Long Sand to the south-west, is probably taken from the "girdle," or griddle for baking cakes (it is spelt Gridler in a chart of 1719), and this receives some support from the contiguous "Pan Sand." Variants of the word "Knoll" are found in the forms Knowles, Knob, and Knock (*e.g.* Kentish Knock and Knock John to the north of the Long Sand). The Gabbards, where a battle was fought in 1653, may be taken from the old name for a small sailing vessel (written also Gabert). A chart by W. Borough, 1588, indicates the courses followed by ships at that date, lying mostly fairly near the Kent and Essex coasts, though one available for small "hoys" and boats runs more centrally to the south of the Long Sand. In this area there was a series of "Knowls" imperfectly surveyed until the nineteenth century, which blocked the entrance for big ships, forcing them to use the channels nearer the Essex side. So far back as 1586 Waghenaer shows a Queen Elizabeth's Channel running south of the Knowls, but no accurate picture of this channel is to be found until Grosvenor and Bean's chart of 1786. The next channel to the north, Prince's Channel, appears in Murdock Mackenzie's official chart of 1775, and must have been so named after either George III or George IV, when Prince of Wales. The banks to the north of it, the Girdler and the Shingles, have an intricate history, changing both their form and nomenclature, the latter name coming in time to be applied to what was previously the East Girdler. Between this and the West Girdler the Alexandra Channel seems to have been opened about 1862, but it has now fallen out of use. Farther north, between the Girdler (Shingles) and the Long Sand, the Duke of Edinburgh's Channel began as a shallow passage known first as the Smuggler's Swash-way, and later in turn as Thomas's and Bullock's Channel. It deepened in course of time, but of late years a bank has formed in its centre and only the passage to the south of it is likely to remain available for ships of deep draught. This leads to the Black Deep, the main longitudinal channel north of the Long Sand, which, though in use in the sixteenth century, is not now frequented by shipping, for though deep and with no known danger, it has never been buoyed.

Dr. Evans's previous articles have been referred to in the *Journal*, vol. 74, p. 606; vol. 77, p. 197.

THE SOURCE OF THE GARONNE

Strangely enough, the question of the ultimate source of so well-known a river as the Garonne remained unsolved until last year. Of the two mountain torrents which unite to form the river before its entry into French territory near the small town of St. Béat, the eastern has been taken as the "official" head-stream, while the western is derived from a more copious source known as the Goueil de Jouéou. On the opposite side of the visible crest of the water-parting there is a swallow-hole in the limestone known as the Trou du Toro, in which a powerful torrent derived from the glaciers of Maladetta is engulfed, and it had long been the popular opinion that the water took an underground course to the Garonne, rather than the more natural one to the Esera (a tributary of the Ebro) in the upper valley of which the point of disappearance lies. This opinion was held so far back as 1787 by the well-known explorer of the Pyrenees, Ramond, but rested on no definite proof. The region is a confused labyrinth of rocks and its exploration is no easy task. An attempt to solve the problem by the use of colouring matter was made over thirty years ago by the French limnologist Emile Belloc, who had urged the total absence of proof for the popular opinion. No definite results were gained, but his operations confirmed M. Belloc in his view that the engulfed water made its way to the Esera. This did not satisfy the well-known French speleologist E. A. Martel, who still upheld the old view, and thanks largely to his insistence the problem was once more taken up by a young geologist, M. Norbert Casteret, who has briefly described his experiment—the culmination of three years' work in this region—in *L'Illustration* for November 28 last. In company with his wife and three other ladies M. Casteret reached the Trou in July 1931, taking with him 60 kilos. of fluorescine to be dumped into the torrent at its point of disappearance. The immediate result of the operation, performed in the dusk of evening, is described as magical, the whole torrent taking on the most vivid colouring. After an uneasy night the party divided, and in spite of unfavourable weather, M. Casteret pushed rapidly across the pass leading to the Goueil de Jouéou, arriving in time to find the coloration well maintained at the emergence, where it had already occasioned some consternation in the minds of the inhabitants. On the other hand a four days' careful watch at the source of the Esera revealed no coloration at all. The question of the ultimate source of the Garonne was thus triumphantly settled, the water which enters the Trou du Toro being proved to take an underground course of 4 km. beneath the fissured limestone mass of the Tusse Blanche. The question has a practical bearing, since the supply of water to the Upper Garonne would be seriously affected by proposed hydro-electric operations on the Spanish side.

SURVEY OF BERLIN

An interesting historical sketch of the survey and mapping of Berlin is given by P. Eichberg, Director of the Central Office for the survey of the city, in the *Mitteilungen des Reichsamts für Landesaufnahme*, Nr. 3, 1931–32. The earliest known plan dates from 1648, being due to the Dutch engineer Memhard. This plan, of which a reduced facsimile accompanies the paper, shows the relatively small area then occupied by the city. During the next three centuries a large number of plans appeared, but mostly of a somewhat sketchy or partial character, as called for by the needs of the Administration. The responsibility for such work long remained with the State Government, and only when entrusted to the municipality by the law of 1875 (recently extended by the agreement of 1931) were the first steps taken for a precise survey answering to modern requirements. During the next twenty-three years the work was carried on under the capable management of Knud von Hoëgh, supported by some forty assistants

of the higher or lower grade. With a central triangulation station at Marienkirche, seven first-order triangles were established in such a way that their bases formed a polygon surrounding the city as then constituted, within which the complete net based on some 3000 points was developed. The survey was plotted on the scale of 1 : 250, with reductions, in part by the help of photography, to those of 1 : 1000, 1 : 4000, 1 : 10,000, and 1 : 15,000. Work for the revision of the sheets has of course been kept going, and special plans have been produced as needed by the various branches of the administration. It has not been found practicable to seek the aid of aerial survey. With the extension of the limits of the city by the law of 1920 it became necessary to extend the survey to the newly incorporated districts, which brought up the whole area to be dealt with from 65 to 878 square kilometres. Of the added area only a small part had so far been at all accurately surveyed, over 600 kilometres being new ground from this point of view. Financial stringency forbade the extreme precision which had applied to the central area, and it has been necessary to have recourse in part to existing material for the final detail while supplying the general framework by more rigorous methods. For this extended area use is being made of the air-plan brought out in 1928–29 on the scale of 1 : 4000.

POPULATION OF FRANCE, 1801–1926

The movement of population in France between the years 1801 and 1926, with special reference to areas of depopulation, is analysed by Erich Weber in *Petermanns Mitteilungen*, Hf 9/10, 1931. The study is illustrated by a number of maps in colour, one series showing the density by departments for six selected years, a second, the percentage increase or decrease. He begins with some figures which illustrate the well-known fact of the relative decline in the population of France: during the 125 years examined the increase in France has been 46 per cent., yet, to take two other countries by no means exceptional, the increase in England has been 198 per cent., and in Spain 110 per cent. Even this increase has not been spread evenly throughout the country—nearly one-third has been in Paris and the Department of the Seine, and if to this is added the industrial areas of the Nord, Pas de Calais, Lyon, and Marseille, two-thirds of the total increase is found to be concentrated in 5 per cent. of the area. Consequently, twenty-five departments have smaller populations than in 1801; six of these are in the Garonne basin, seven in Normandy–Maine, six in the eastern Paris basin, four in the Alps, but only two in the Central Plateau.

The average density of population in 1801 was 51 per sq. km., a figure which compared well with those for contemporary states. For the first forty-five years the rate of growth was generally good, and in 1846 no department showed a decrease. The population of Finistère had increased by more than 30 per cent., the smallest increases being in Eure, Tarn-et-Garonne, and Jura. The period 1846–1872 marks the first great check to the growth, and the concentration in the large industrial centres. In 1872 forty-four departments had fewer inhabitants than in 1846. There was then a slight check to the progress of depopulation—though in 1886 twenty-seven departments had declined—but the rate then increased greatly, and has continued practically to the present time. Between 1886 and 1911 many departments lost more than twice as many inhabitants than in the years 1846–72; between 1911 and 1921 seven departments only showed an increase; and in the following five years thirty departments declined, despite immigration. It is not possible here to designate in detail the fluctuation of areas and rates of decline, the chief being in the Pyrenees, Alps, the north-eastern frontier, portions of the Central Plateau, the Garonne basin, and Normandy.

The writer then examines several particular cases, to ascertain how far this depopulation is due to geographical factors. The Basses-Alpes had a density of 19 per sq. km. in 1801; this increased fairly steadily to the maximum, 23, in 1836; since then it has declined continuously to 13 in 1926. This has been explained by the progress of deforestation and the destruction of home industries by industrial competition. A contributory factor has been the decline of the birth-rate and the maintenance of a high mortality.

Despite the unproductive *causses*, Lot had a density in 1801 equal to the average for France, *i.e.* 50; by the middle of the century it had grown to 57; for 1926 the figure was 33. The writer argues that the mortality, low birth-rate, and migration which have contributed to this result are not the outcome of geographical conditions. Mortality depends largely upon defective sanitation, and it is not to be supposed that the soil of France is not capable of supporting as many people as in 1801. The real cause is "weltanschaulich"—the rise in the standard of living, and all its concomitants. Some of the poorest departments have a high birth-rate, which has checked the rate of decline: Lozère has declined only 27 per cent. between 1846–1926, less than certain more fertile departments of the Garonne and Normandy, *e.g.* Tarn-et-Garonne, 32·3 per cent., and Manche, in 1801 one of the most densely peopled areas, 28·6 per cent. His chief example that the depopulation has no geographical cause is drawn from Finistère: this is one of the least-favoured areas, yet a density of 62 in 1801 was transformed into one of 115 in 1911. The conservatism of the Breton has resisted the attraction of the industrial centres.

THE GLACIERS OF KILIMANJARO

Professor Fritz Jaeger, in his time one of the most careful observers of the glacial phenomena of Kilimanjaro, has been at pains to put together (*Zeitschrift für Glaciologie*, August 1931) a tabulated statement of the condition of the ice at various points at the dates of the visits of different travellers, as deduced from their photographs. He begins with a careful survey of the ice conditions of the summit of Kibo, pointing out that owing to its regular form there are no true valley glaciers fed by basins of *névé*, but that there is merely a cap of *névé* and ice, with projecting tongues comparable to hanging glaciers. Since the chief precipitation is due to the south-west wind (a sort of reflex of the anti-trade which blows from the north-east) the cap is tilted, coming much lower on the south-west. It might be thought that the level interior of the crater would be an ideal collecting ground for *névé* and that a large valley glacier would pour down through the western breach into the trench by which the mountain is furrowed on this side, and the absence of such a glacier and the general distribution of the ice-masses indicates that wasting is active in the crater, the causes of which are uncertain. It is conceivable that the melting might be due to a remnant of volcanic heat, for Mittelholzer's air-photographs show how sharp and steep is the inner crater-ring, pointing to a recent origin. But the explanation may lie in the local climatic conditions, *e.g.* the prevalence of dry north-east winds may place the crater on the border-line between supply and waste, one or other of which may prevail according to circumstances. The records show that deep snow may be present in the crater at almost any time of year, so that the falls do not seem limited to the rainy season at lower levels. The freshly fallen snow seems to stretch down regularly to an even level, but the older masses are distributed according as the position of the sun at different seasons makes the north or the south side the sunny one. There seems no doubt that there has been a continued decrease in the amount of *névé* and ice since Hans Meyer's first observations in 1887. The writer ends by urging systematic observations by trained Alpinists,

who might camp for a time near the summit, and would find the difficulties not to be compared with those of a Himalaya expedition.

RETREAT OF THE MUIR GLACIER, ALASKA

According to Mr. C. L. Andrews, writing in *The Mountaineer* (Seattle, Washington, vol. xxiv, December 1931), the Muir Glacier, in Glacier Bay, south-east Alaska, presents the greatest change in recession of the ice in a short period of time ever recorded. John Muir, who discovered this grand glacier in 1879, stated that the area drained by it could hardly be less than 700 or 800 square miles, and that it probably contained as much ice as all the eleven hundred Swiss glaciers combined. When first visited by Mr. Andrews in 1892 the whole glacier was magnificent and greatly exceeded the Taku Glacier which is now the more conspicuous on the tourist route. In 1903 the glacier had much receded, and in 1913 the recession had amounted to 11 miles on the main trunk and 7 miles on one of the tributaries. Sections of U.S. Coast and Geodetic Survey charts published in 1899 and 1929 indicate the extent of the changes which have taken place, several tributary glaciers having disappeared, leaving only moraines in the position formerly occupied by their fronts. It would appear that an earthquake which visited this coast in October 1899 and caused great masses of ice to be discharged into Glacier Bay disturbed the equilibrium of the Muir system to an extent that may be responsible for the abnormal rate of recession recorded, although recession of the mountain glaciers of Alaska is general. According to a recent memoir by Mr. Stephen R. Capps (U.S. Geol. Surv., Prof. Paper 170–A), which deals with Alaskan glaciation as a whole, the interior of Alaska because of its dry climate escaped the North American continental ice-sheet, but the mountains were at that time far more heavily glaciated than now. It is thought likely that the present recession of the mountain glaciers may represent only an interglacial stage at or near the maximum phase of deglaciation.

THE BARTLETT TROUGH, WEST INDIES

In the *Journal of Geology* for August and September 1931 Mr. Stephen Taber draws attention to the importance of studying the great submarine troughs about which little is known, though they are comparable in magnitude with mountain ranges. He considers the problem of the Bartlett trough in the West Indies which, having land areas on both sides, offers many advantages for research. It extends in a flat arc, convex towards the north, from the Gulf of Honduras eastward as far as Gonaive Gulf between the two western peninsulas of Haiti, a distance of 1570 kilometres. Its greatest width is about 160 kilometres, and greatest depth 6412 metres, or over 8000 metres beneath the higher peaks of the Sierra Maestra in Cuba on the north and the Blue Mountains in Jamaica on the south. Soundings indicate extensive flat areas over much of the central part of the trough which has precipitous scarps on both sides, but near the base of these scarps there are subsidiary troughs which are continued beyond the Bartlett Trough as the great northern and southern valleys of the island of Haiti.

Although it is generally agreed that the trough is tectonic in origin there have been considerable differences of opinion as to the relative importance of folding and faulting in its formation. Mr. Taber points out that the precipitous scarps indicate faulting rather than folding, and that the localization of earthquakes near its margins is proof that faulting is going on in these belts at the present time. He has also found geological evidence of recent faulting near the northern margin of the trough in the island of Cuba.

In this part of the West Indies vast quantities of volcanic material were piled on the earth's surface during Cretaceous and Tertiary times, and this excess of

material, it is thought, may be connected with the tendency to subsidence at the present time.

The author advocates an extensive system of gravity determinations for continuing the investigation of the origin and structure of the Bartlett Trough, which is a big problem requiring the co-operation of geologists, geodesists, and seismologists.

LIMITS OF THE AUSTRALIAN DESERT

Professor Griffith Taylor who, as is well known, is no optimist concerning the possibilities of settlement in the heart of Australia, considers the limits of the desert in an interesting contribution to *Gerlands Beiträge zur Geophysik* (Bd. 33—Köppen, Bd. II, 1931). The limits determined by Köppen are decided solely by climatic considerations involving a numerical relation between temperature and rainfall, in which the proportion of rainfall is higher in the hotter northern regions of the continent. This arid region as determined by Köppen's ingenious method, comprising as much as 1,100,000 square miles in the central and western parts of Australia, is divided by Professor Taylor into a central region of true uninhabited desert and a peripheral zone where sparse settlement by pastoralists is possible. The outer belt, comprising an area of some 700,000 square miles with a human population of only 15,000, is limited by the dry climatic conditions of the trade winds; but the true desert area of 500,000 square miles is differentiated, not by greater aridity of climate than prevails in much of the outer zone, but by geological factors favouring an extensive development of dunes where practically no forage exists. There are however no *ergs* or "living" dunes of any extent in Australia, which is attributed by Professor Taylor to the fact that the rainfall is greater than in the Sahara. Although ground water everywhere exists there are absolutely no rivers in Professor Taylor's central area, and they only occasionally flow in the outer sparse lands; even the Murray sometimes ceases to run. Hence irrigation will never make any essential difference to the vast arid extent of Australia, and artesian water is only available in the south-eastern part of the arid region.

Finally, Professor Taylor attempts to give a combined climatic and economic definition, including a time factor, of his restricted desert area in the following terms applicable to Australian conditions: "A desert is a region of small rainfall (sometimes however amounting to 15 inches in hot regions) with a sparse and specialized plant and animal life. It is not found capable of utilization by pastoralists, even after the borders have been occupied by this class for fifty years." It should be added that Professor Taylor has extensive personal experience of arid Australia. He suggests that the definition of a desert would make a useful topic for a forthcoming geographical congress.

OLD PICTURES OF CHINESE CITIES

We have recently exhibited in the Ambulatory three photographs from paintings in Mr. David Minlore's collection. Mr. Minlore has specialized in old views of Chinese cities, many of which are without titles, and it was hoped to arrive at the identification of the three posted in the Society's House. No one however has volunteered any knowledge of the places represented, and Mr. Minlore is so good as to suggest that any Fellow who is interested in the history or geography of China or in old ships would be welcome to see his collection at any time at Wildwood House, N.W.11.

BIBLIOGRAPHIE GÉOGRAPHIQUE 1930

The 'Bibliographie Géographique,' vol. 40, 1930, is now ready for distribution, and may be obtained from the Chief Clerk at the Society's House. The adverse movement of the exchange makes it necessary to fix the price of this

volume at 12*s* 6*d*, post free, for the British Isles and Dominions, if ordered from the Society. It would greatly simplify distribution if subscribers would give a standing order. The price of future volumes must depend upon the rate of exchange: previous volumes from 1926 may still be obtained from the Society at 8*s* 6*d*, post free, until the stock held is exhausted.

The volume for 1930 has 2780 main entries, many of them containing twenty or more bibliographical references, and a forty-page index of authors. The value of the work to geographical students is apparent, and the co-operation of geographers in making it as widely known as possible would be appreciated.

OBITUARY

JOHN STORY MASTERMAN

Mr. John Story Masterman, who became a Fellow of the Royal Geographical Society in 1890, died at Dorking on 4 December 1931 at the age of eighty-two. An ancestor on his mother's side was Dr. Nevil Maskelyne, Astronomer Royal, who made the historic first determination of the mass of the Earth by pendulum observations round Schehallion in Perthshire. Mr. Masterman was educated at Rugby under Dr. Temple and at Corpus Christi College, Oxford, later becoming a Fellow of Brasenose. As assistant master at University College School, London, he was one of the earliest and most assiduous of Mr. B. B. Dickinson's colleagues in his advocacy of the use of geographical lantern slides in schools, which led in 1893 to the foundation of the Geographical Association. The Committee of the Association met for many years in Mr. Masterman's house on Campden Hill, and although he always declined any prominent official position he continued to work unobtrusively for the Association until it had reached its present prosperous and highly organized state.

Mr. Masterman was an enthusiastic ornithologist, and his collection of the eggs of British birds came within a measurable distance of completeness. His only sport was mountaineering, and he was a member of the Alpine Club since 1895. In Switzerland he spent most of his time above the snow-line with his favourite guides, the brothers Supersaxo. He made his first ascent in 1869, and he left a list of fifty-eight summits all exceeding 10,000 feet which he had attained in the years between 1888 and 1902, when severe frostbite on the Monte Rosa glacier put a stop to his mountaineering.

Mr. Masterman's personal character was singularly attractive, and those who knew him intimately recognized in him a sensitive sympathy, a love of knowledge in many fields, and a generous kindliness towards all in difficulties.

H. R. M.

CORRESPONDENCE

GLACIATION AND CONTINENTAL DRIFT

In the very interesting discussion on Problems of the Earth's Crust, reported in the November number of the *Geographical Journal*, more than one speaker refers to the theories of the late Dr. Wegener in regard to the drift of continents and the wandering of the poles as necessary to account for ice ages, especially for the widespread glaciation in Permo-carboniferous times. Wegener himself

believed that both the Pleistocene and the late Palaeozoic ages were readily accounted for by shiftings of the continental masses and of the poles so as to bring the glaciated regions into latitudes which would imply cold. He illustrated his idea of the necessary arrangement of the land areas and the poles by maps which make the supposed relations very clear ("The Origin of Continents and Oceans," pp. 6, 7, 100, 111, 126). A careful study of the conditions necessary for continental glaciation convinces me however that these two ice ages, instead of supporting his theories, are completely opposed to them. This may be shown by a brief statement of the facts, discussing first the Pleistocene glaciations, of which we know most.

The climatic changes causing the Pleistocene glaciations were not limited to special regions, such as northern Europe and America, but were world-wide. There was a fall of several degrees of temperature in the tropics as well as in temperate and polar regions, and on high mountains everywhere the snow-line was depressed 3000 or 4000 feet. This is proved by ancient moraines at that distance below existing glaciers on the high Andes, on the equatorial mountains of central Africa, on one or two of the highest peaks of New Guinea, and on the Himalayas and other Asiatic ranges. A shift of land masses or of the position of the poles could not have caused this universal lowering of the snow-line on all the continents.

It should be noted also that the relative standing of the different climates was not affected by this world-wide refrigeration, since all were lowered to the same extent. For instance, the highly unfair arrangement of climates about the north Atlantic, by which London has temperatures far milder than its latitude warrants, while Battle Harbour in Labrador, on the same parallel, has cold far beyond its deserts, had its exact equivalent in the ice age. The Scandinavian ice-sheet reached south only to lat. 50°, while the ice-sheets of America pushed south to lat. 38°, a difference of 12 degrees.

Another point of great importance is the fact that the so-called Ice-Age of the Pleistocene was not a time of continuous cold, since the four known glaciations were separated by three interglacial times of milder climate. It was in reality characterized by great oscillations of temperature. Recent work has shown that the four glaciations recognized in the Alps and in England and parts of northern Europe have their equivalents in America, and good authorities, such as Leverett in America and Woldstedt in Germany, consider that the drift deposits left by the four glaciations have undergone about the same amount of weathering and erosion on the two sides of the Atlantic, so that the European and American glaciations were contemporaneous.

Moreover the two best marked sets of moraines on the Rocky Mountains of Canada, the older one more extensive than the later one, have their equivalents on the higher peaks of the American Rockies almost as far as Mexico; and the same is true of the Andes in Ecuador, Peru, Bolivia, and Argentina, ending in Patagonia, where two glaciations and an interglacial period have been described. If the whole 10,000 miles of the American Cordillera, including summits near the equator, show the same two glaciations in the Pleistocene, the older more severe than the later, it is evident that no juggling of continents or displacing of poles can account for the facts. This line of argument might be considerably extended: for instance, to include the Himalayas and Mount Kosiusko in Australia; and there can be no doubt that at least two refrigerations in the Pleistocene affected the whole world contemporaneously.

Another marked feature of the Pleistocene glaciation deserves consideration; the more important ice-sheets, omitting Antarctica, were grouped in an extraordinary way about the North Atlantic, and the centres of the continental

glaciers were not far from warm seas—facts by no means accidental. A large amount of heat is necessary to produce a great ice-sheet, since 1,000,000 cubic miles of water must be evaporated from the sea to be deposited on the land as snow. Thus the vast Scandinavian sheet grew south-westwards toward the most important of the warm ocean currents, and the two greatest ice-sheets of America —those of Labrador and Keewatin together covering 3,000,000 square miles— pushed far southwards when at their maximum until only 550 miles of the wide open Mississippi valley separated them from the steamy Gulf of Mexico. The greatest existing ice-sheet, that of Antarctica, is surrounded on all sides by seas reaching up to the tropics.

Cold alone will not produce an ice-sheet: there must also be an access of moist winds coming from a warm sea, and no important accumulation of ice can take place in the heart of a broad continental area far from sources of evaporation. Siberia, though beside the Arctic Ocean, was not glaciated to any important extent in the Pleistocene. Wegener's map of the supposed arrangement of the northern glaciated areas in the Pleistocene shows Scandinavia, Greenland, Labrador, Newfoundland, and the British Isles huddled together near the Gulf of St. Lawrence, cutting off a main source of evaporation; and his suggestion that the outer terminal moraines of Europe and America "join up smoothly" indicates his belief that the glaciated area was a unit. It is evident that he had not taken into consideration the need for a broad evaporating surface not far off if an ice-sheet is to be built up; but his own references in another part of the book to the isostatic upheaval of an area relieved of its load of ice should have suggested the real condition of affairs. That the Scandinavian and Canadian areas were separate is evident when the fact is recalled that marine beaches on the two sides of the Atlantic rise from the present sea-coast toward each glacial centre and not toward the centre of the North Atlantic as his map would require.

The crowding of the land masses together where the sea now separates them, so that an imaginary north pole could rise in their midst to give them arctic climates, suggests another interesting problem, that of interglacial times. One of these interglacial periods had a climate 4 or 5 degrees warmer than at present, as shown by its forest trees. Were the different countries pushed apart during an interglacial period and closed up again for the next glaciation? Unless some supposition of the kind is made the "drift of continents" cannot account for the three interglacial times of milder climate.

Enough has been said to show that Wegener's theories completely fail to account for salient features of the Pleistocene glaciations. Let us now turn to the more intense and more puzzling ice age which occurred toward the end of the Palaeozoic, when the tropics were invaded by great ice-sheets if the continents occupied their present positions. In Wegener's maps the known glaciated regions, South Africa, India, Australia, and South America, along with Antarctica, are represented as crowded together, South Africa in the centre with the south pole wandering across it. This arrangement places the regions where tillites have been found within a reasonable distance of the pole, not greater than that of the glaciated upper Mississippi valley from the north pole in the Pleistocene, and at first glance seems to give a welcome explanation of a most difficult set of conditions. It is not surprising that some geologists and geographers have accepted it with relief as disposing of a hitherto insoluble problem.

A closer study shows that here also the bold shifting of continents fails to meet the requirements. It is well known that continental ice-sheets move in all directions out from a centre. They cannot move in a one-sided way like a mountain glacier, where the slope of the valley determines the direction of motion. It is the gradient of the surface of the ice itself which pushes the bottom layers

outward on all sides, transporting materials and striating the rock beneath in a radiating way, and every great ice-cap must obey this law, even if it pushes for long distances uphill, as in the case of the Keewatin glacier of the Pleistocene.

The vast Permo-carboniferous ice-sheets have left evidence of their work over hundreds of thousands of square miles, but it is a curious fact that at least three of the glaciated regions show motion only in one direction: in South Africa toward the south or south-west, in India toward the north, and in Australia also to the north. It appears that great as the known glaciated areas are, we have found only half of the original drift-covered surfaces. The evidence for the other half has been buried under later rocks, or has been destroyed during the many millions of years that have elapsed since the Palaeozoic ended, or perhaps merely has not been sufficiently looked for.

This feature is specially striking in South Africa, where magnificent proofs of the work of the great ice-sheet and of its southward movement are found in many parts of the carefully mapped Union of South Africa, while very little is known of the northern half of the ice-sheet, which must have reached far into the tropics. Reports of Dwyka-like tillites at scattered points in Togoland and Katanga suggest that even the equator was not exempt from glaciation ('Ice Ages Recent and Ancient,' pp. 132, etc.). In India and Australia, also, half of the glaciated area seems to be missing, the geologists of the latter country believing that the invading ice came on a broad front from a vanished land to the south to which they have given the name Tasmantis.

The massed southern continents shown on Wegener's map already cover so vast a space that the interior would be thousands of miles from the nearest sea and would probably be as arid and snowless as the desert of Gobi; but the doubling of the glaciated area, as suggested above, would make it still more improbable that sufficient snowfall could reach the central regions about the pole to form the tremendous *névé* the theory suggests. Judging from conditions in the Pleistocene, when all the glaciated regions were within reach of moist winds coming from the open sea, the assumption seems impossible.

When Wegener massed the southern continents in a huge Gondwana land he was certainly not aware of one very serious difficulty opposing his theory; namely, that on all four of the great glaciated areas there is evidence that the ice-sheets reached the sea. In each of the continents the tillites are associated at one or more points with marine deposits, and sea shells even occur in the matrix of the tillite in New South Wales. In Australia and South America the sea washed the glaciated regions on both sides, and in India marine beds occur with the tillite at points hundreds of miles apart (*ibid.*). This evidence of open sea near the ice-sheets is, of course, what might be expected from the history of the Pleistocene glaciation; but it thrusts apart the continents crowded together in Gondwana land and makes it still more certain that the ice-sheets would reach tropical latitudes. The marine associations of the Permo-carboniferous tillites just referred to cut the ground from under another theory held by some geologists, that this ancient glaciation was due to elevation. The ice-covered regions were not lofty tablelands, cold because of their height, but came down to the sea at several places, just as happened in the Pleistocene.

Enough has been noted to show that theories of drifting continents and wandering poles are entirely inadequate to account for the known facts in regard to the two greatest times of glaciation; and what caused the development of great ice-sheets at the end of the Palaeozoic in regions now tropical remains as mysterious as ever.

A. P. COLEMAN

Royal Ontario Museum, Toronto. 6 *January* 1932.

MEETINGS: SESSION 1931–1932

Sixth Evening Meeting, 25 January 1932. The President in the Chair

Elections: H. F. T. Adam; Major H. F. T. Blowey, O.B.E., A.M.I.A.E.; Lt.-Commr. John H. Bowen, R.N.; William Henry Buffum; Sidney Howard Burt; Stanley John Cannicott; Miss Norah H. Cumberland; Christopher T. Dalgety; Mrs. Margery E. Dick; Isaac William Dickinson; Miss Celestine M. D'Souza; John Gillespie; Capt. Henry E. Gilroy, O.B.E., R.N.R.; The Hon. Lady Goodenough, O.B.E.; Kenneth A. Goudge; Brian Weston Greene; Harry Gregson; Seaward Harcourt-Rivington; Graham S. P. Heywood; Mrs. Godfrey Holdich; The Rev. R. D. Hudson, M.A.; Frederick Nevill Jackson; Aleko E. Lilius; Mrs. Dora M. H. Longstaff; Sir Arthur Cecil McWatters, C.I.E.; Edwin George Malcolm, B.SC.; The Rev. David Henry Moore; The Rev. W. W. C. Lipscomb Orpwood, M.A.; Ernest Guy Pack; Douglas MacDonald Ramsden, M.SC.; Michael Dennis Rogerson; Raj Behari Seth; Rev. Alfred Sills; Mornington Soosainaden; Cyril Styring, LL.B.; Capt. T. Sutherland, R.N.R.; The Rev. Richard Martin Taylor, F.R.E.S.; Mrs. Lilian Stuart Todd; Mrs. Gladys Winifred Unwin; Miss Jean Willett.

Paper: Lakes of Kenya and Uganda. By Dr. E. B. Worthington

Seventh Evening Meeting, 8 February 1932. The President in the Chair

Elections: The Rev. Charles Richard Davey Biggs, M.A., D.D.; Mrs. Gertrude Beatrice Alexandra Bonnett; George Hugh Cutbush; Mrs. Edith Mary de Kat; Thomas William Hamilton Dee; William Alfred Bathurst Douglas; Capt. Norman Eric Franklin; Charles Richmond John Glover, B.A.; Charles Innes, O.B.E., B.SC., M.I.C.E.; Miss Florence F. Laidler, M.SC.; Miss Elsie Pemberton Leach; Arthur Lloyd-Jones; William Henry Lucy; Hugh Edmund Pacey, B.A.; Mrs. Edith Mary Pellier-Johnson; Boies Penrose; Iain Ramsay; Mrs. Charlotte Seymour Sclater, C.B.E.; Alexander John Patrick Sellar; Mrs. Mary Ahnighite Peary Stafford; Mrs. Gertrude Adeline Taylor; Arthur Reginald Villar; Mrs. Muriel Ethel Faulkner Willoughby; J. W. Woods.

Paper: The Oxford Expedition to Akpatok Island. By Mr. Hugh Clutterbuck

Fourth Afternoon Meeting, 15 February 1932. The President in the Chair

Paper: The New Photographic Survey of Switzerland. By Mr. Michael Spender

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